16

INTERIM REPORT

DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

June 1978

by

G. B. Mitchell, Yu-Shih Jeng

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
13 Jun 78

3. REPORT TYPE AND DATES COVERED
Interim 9 Nov 77 - 23 May 78

4. TITLE AND SUBTITLE
Dike Stability Analysis, Basin F, Rocky Mountain Arsenal, Denver, Colorado

5. FUNDING NUMBERS

6. AUTHOR(S)
G. B. Mitchell
Yu-Shih Jeng

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180

8. PERFORMING ORGANIZATION REPORT NUMBER
81266R44

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This report presents the findings of the U. S. Army Engineer Waterways Experiment Station in compliance with the appropriate portions of Task 1.05.62. The work to be performed under Task 1.05.62 is defined as; Quantitative Feasibility Evaluation for Full Depth Containment of Basin F, and states, in part, that "Any hazards to the existing dikes due to age or construction should be identified" and "Assess the current physical condition of the Basin for determination of need for immediate structural repair."

14. SUBJECT TERMS
Treatment, Disposal, Liners

15. NUMBER OF PAGES
91

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

INTERIM REPORT

DIKE STABILITY ANALYSIS

BASIN F

ROCKY MOUNTAIN ARSENAL

DENVER, COLORADO

June 1978

by

G. B. Mitchell, Yu-Shih Jeng

[redacted]

U. S. Army Engineer
Waterways Experiment Station

13 June 1978

DIKE STABILITY ANALYSIS, BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, CO

1. This analysis was performed during the period 9 November 1977 - 23 May 1978. The study was authorized by Intra-Army Order for Reimbursable Services (IAO) No. RM 56-78 dated 9 November 1977. A Work Statement attached to that IAO defines the work to be performed under Task 1.05.62, Quantitative Feasibility Evaluation for Full-Depth Containment of Basin F, and states, in part, that "Any hazards to the existing dikes due to age or construction should be identified" and "Assess the current physical condition of the Basin for determination of need for immediate structural repair." This report presents the findings of the U. S. Army Engineer Waterways Experiment Station (WES) in compliance with the appropriate portions of Task 1.05.62.

2. A visual on-site inspection was made of the dike, and four boring locations were selected. A plan view of Basin F, along with the boring locations, is shown in Figure 1. The initial borings were made by a WES drill crew operating a drill rig belonging to Rocky Mountain Arsenal (RMA). The rig was not equipped to obtain satisfactory undisturbed samples, and in order to expedite the investigation, the borings were made utilizing Standard Penetration Tests (SPT). Jar samples were obtained and tested in the WES Soil Testing Facility for moisture content, Atterberg limits, grain-size distribution, and specific gravity. The laboratory test results are presented in Figures 2-41. The graphic boring logs and results of the SPT tests are presented in Figures 42-45.

3. From the SPT and laboratory test results, shear strength and unit weight parameters were estimated. The soils were considered to be either cohesive (in which case no angle of internal friction was assigned) or cohesionless (in which case no cohesion was assigned).

These estimated values are presented in Figures 42-45. Stability analyses were performed by using the Wedge Method in the WES Computer Program SSW028.

4. It appeared from the calculated factors of safety (0.87 to 1.25) that a critical condition existed in the outside, or downstream, slope when the reservoir was at full pool (2 ft below the crest) and when a steady seepage state with an assumed phreatic line occurred through the dike. Since the reservoir has been at full pool and the dike has not failed, it was felt that either the estimated strength values were not valid or the asphaltic membrane liner on the upstream slope had been effective in preventing a steady seepage state from occurring and the conditions necessary to reduce strength to that for saturated drained conditions have not yet developed. (The laboratory tests indicate that the embankment zone below the assumed phreatic line is not saturated.) Since the possibility exists that the liner could become ineffective at some point at any time, and since the low factors of safety were calculated from estimated soil parameters, it was felt that additional borings to obtain undisturbed soil samples for more accurate laboratory testing were necessary.

5. Four additional borings were made within 5 ft of the initial borings by a WES drill crew using a WES drill rig. Undisturbed Shelby-tube samples, 5 in. in diameter, were obtained. Where the soil possessed sufficient cohesion, Q triaxial tests were performed; where the soil possessed low cohesion, S direct shear tests were performed. All test results are presented in Figures 46-79. A comparison of the initial estimated values and the measured laboratory values indicates that the estimated values were only slightly in error. Since several samples were tested from each zone, and since the values within a zone varied slightly, it was necessary to make statistical selections of values for use in the analyses. The selected soil parameters for respective zones are shown, along with the initial graphic borings logs and estimated values, in Figures 42-45. Stability analyses were performed

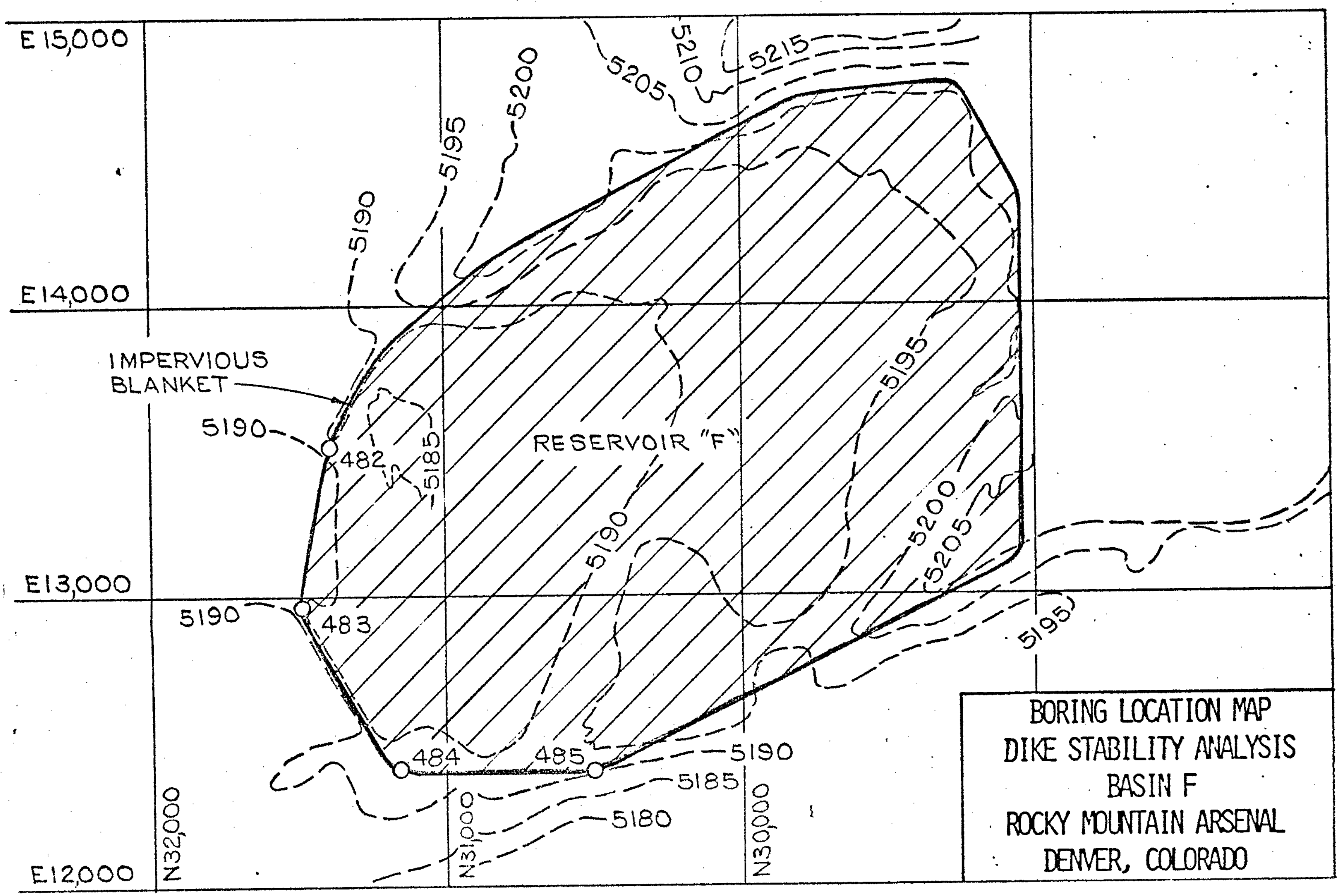
utilizing the selected values and the Modified Swedish Method in the CORPS Computer Program I0009. Only the downstream slope was evaluated. Again, pool level was assumed to be 2 ft below the crest. Analyses were also performed with a pseudo-seismic (earthquake) loading of 0.05 g. The analyses are presented in Figures 80-83.

6. The analyses revealed that the factors of safety are highly dependent upon the degree of cohesion. Figure 84 graphically depicts this sensitivity. Corps of Engineers (CE) criteria, however, dictate that the SS case be analyzed using the drained strength (S test), which in this case is without cohesion. On this basis, factors of safety of 0.79 to 1.11 were obtained. Because of the sensitivity of the factors of safety to cohesion, analyses were also performed using the undrained strength (Q test) which includes cohesion and represents the unsaturated "as is" condition of the dike. Factors of safety for this condition range from 4.43 to 9.80. A summary of all factors of safety is presented in Figure 85.

7. Because of the low factors of safety indicated for the SS case, further analyses were performed with the reservoir pool lowered by 2-ft increments to determine if a lower head would increase the factor of safety to 1.5 as required by CE criteria for the SS case. (We understand that the reservoir pool elevation is decreasing due to reduction and possible complete cessation of fluid discharge into the basin.) Boring 482 was selected as being representative and only this location was subjected to the additional analyses which were performed using both S and Q strengths and with and without earthquake loadings. The results are shown graphically in Figure 86. Increases in factors of safety were only slight.

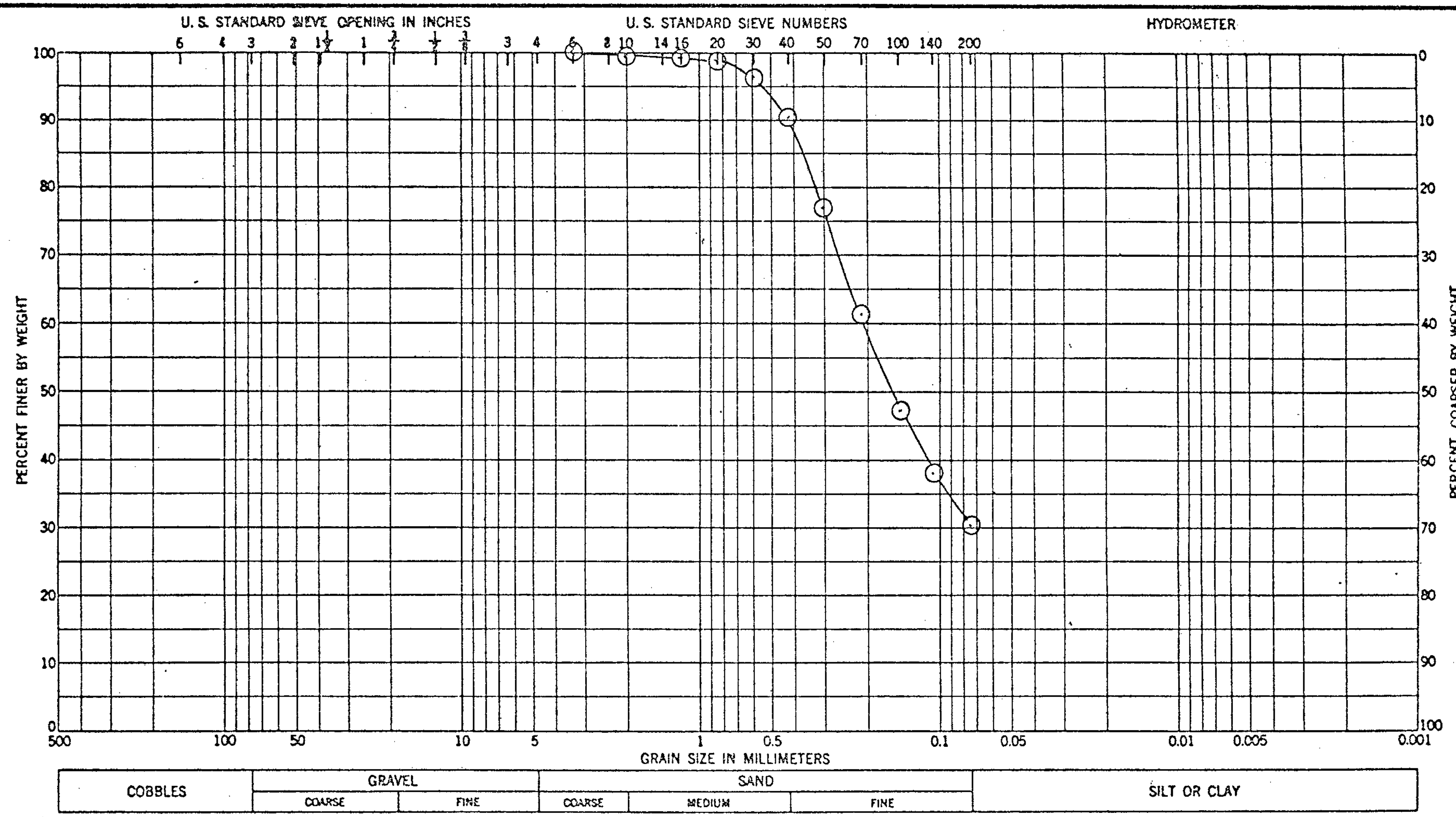
8. A summary of all analyses indicates that in order to comply with current CE criteria of a factor of safety of 1.5 for the SS condition, the downstream dike slope must be altered from its present 1:1 to a flatter 1:2.5. It is estimated that the dike comprises approximately one-half of the total periphery of the basin; consequently,

approximately 3600 lin ft of dike must be altered. The alteration will require approximately 16,000 cu yd of soil. The operation should be fairly simple and can be accomplished by stripping soil from around the periphery with a bulldozer and shoving it up onto the existing slope. The absence of significant vegetation in the surrounding topsoil and on the dike slope should expedite the operation. The peripheral fence must be removed and replaced along the length of dike addressed.



BORING LOCATION MAP
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO
RESERVOIR "F"
IMPERVIOUS BLANKET
482
483
484
485
E15,000
E14,000
E13,000
E12,000
N32,000
N31,000
N30,000
5215
5210
5205
5200
5195
5190
5185
5180

Figure 1



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0-1.5	SILTY SAND(SM) BROWN	8.1	NP		
		Gs = 2.70				

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

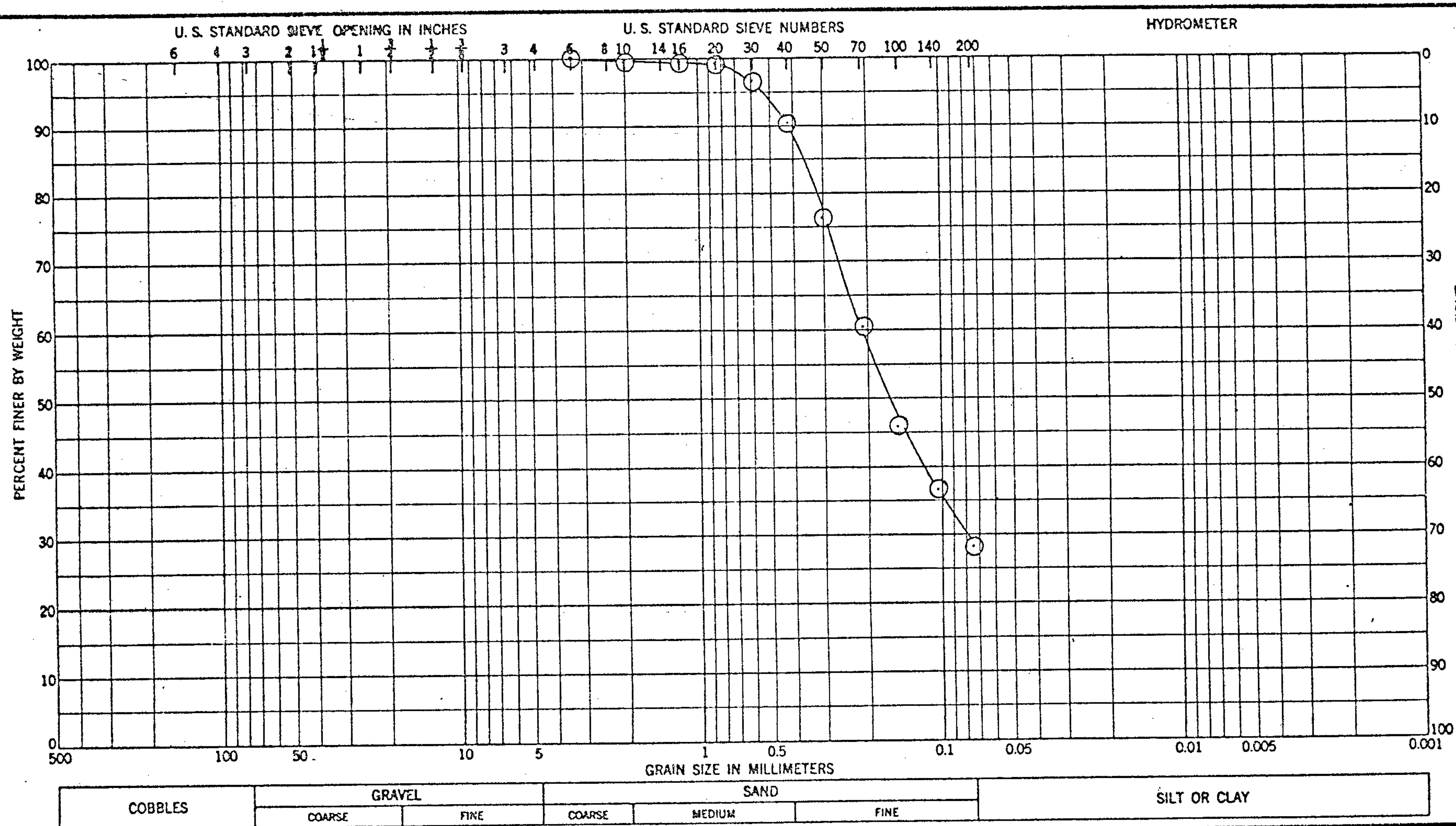
Boring No. 482

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 2



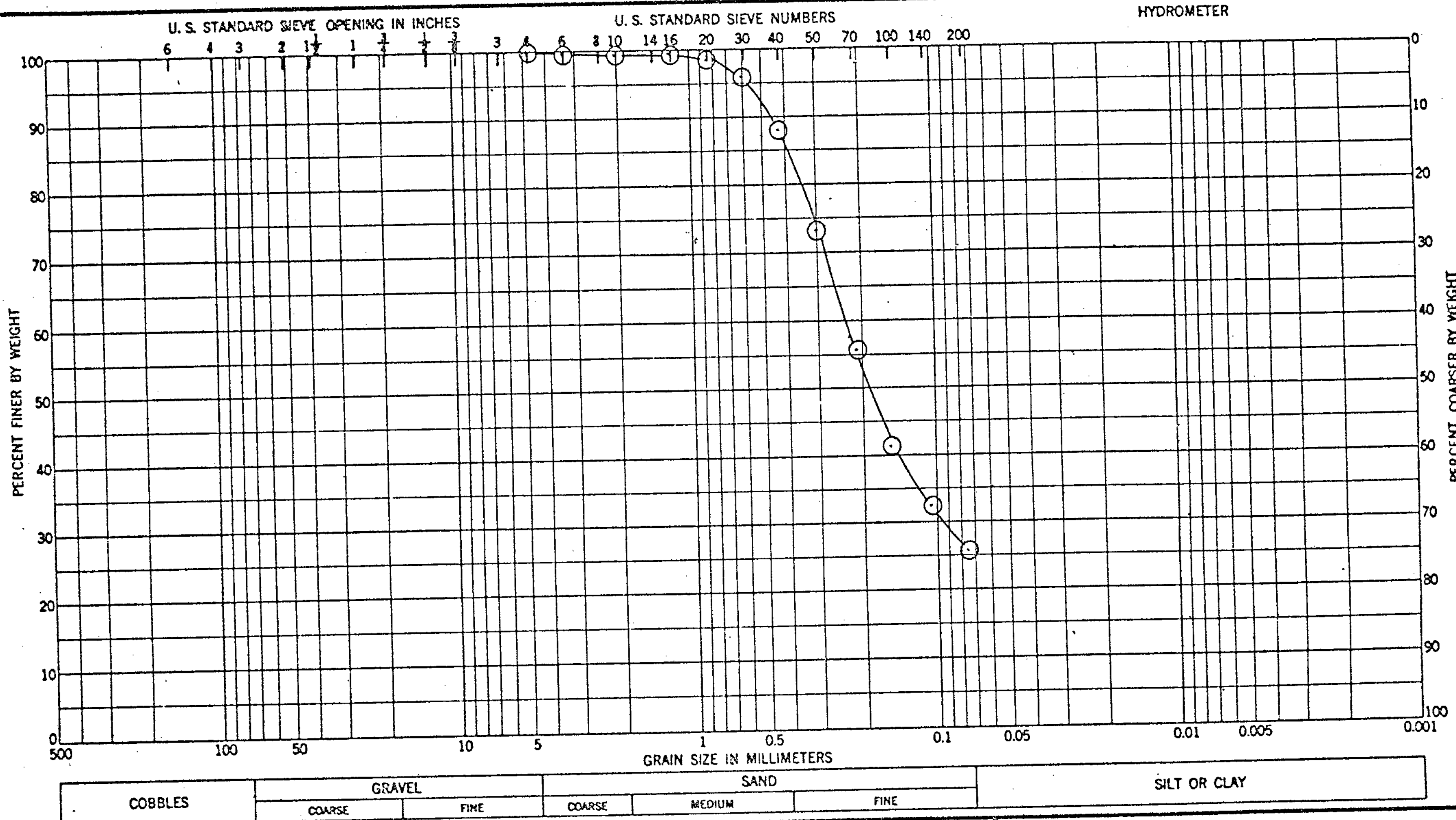
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	2.0-3.5	SILTY SAND(SM) BROWN	8.5	NP		
		Gs= 2.70				

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	482
Date	28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 3



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	4.7-6.2	SILTY SAND(SM) BROWN Gs= 2.70	9.1	NP		

Project: ROCKY MOUNTAIN ARSENAL

Area: F BASIN - DIKE

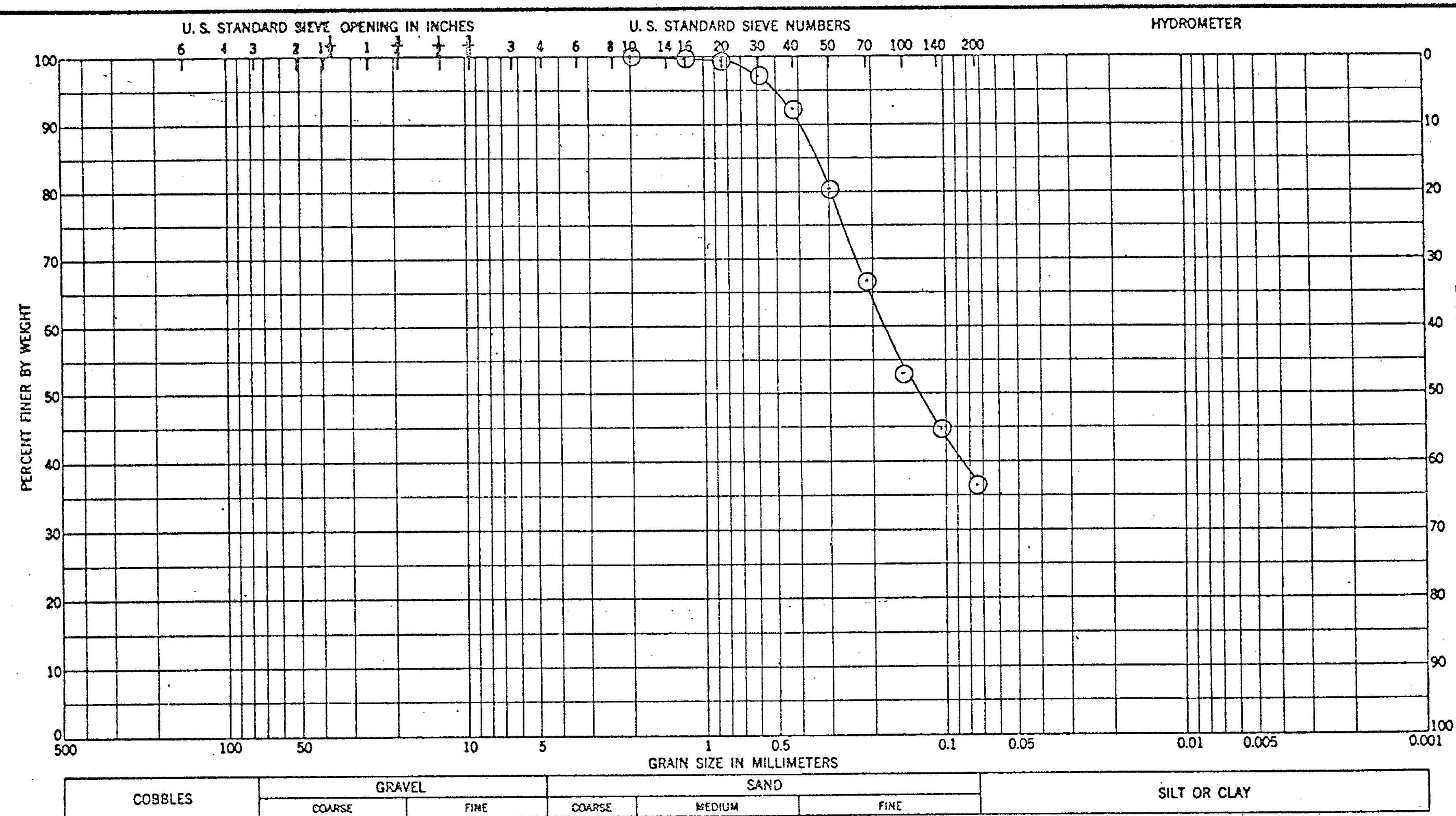
Boring No.: 482

Date: 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 4



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	7.5-9.0	SILTY SAND(SM) BROWN	13.5	NP		
		Gs= 2.72				

Project: ROCKY MOUNTAIN ARSENAL

Area: F. BASIN - DIKE

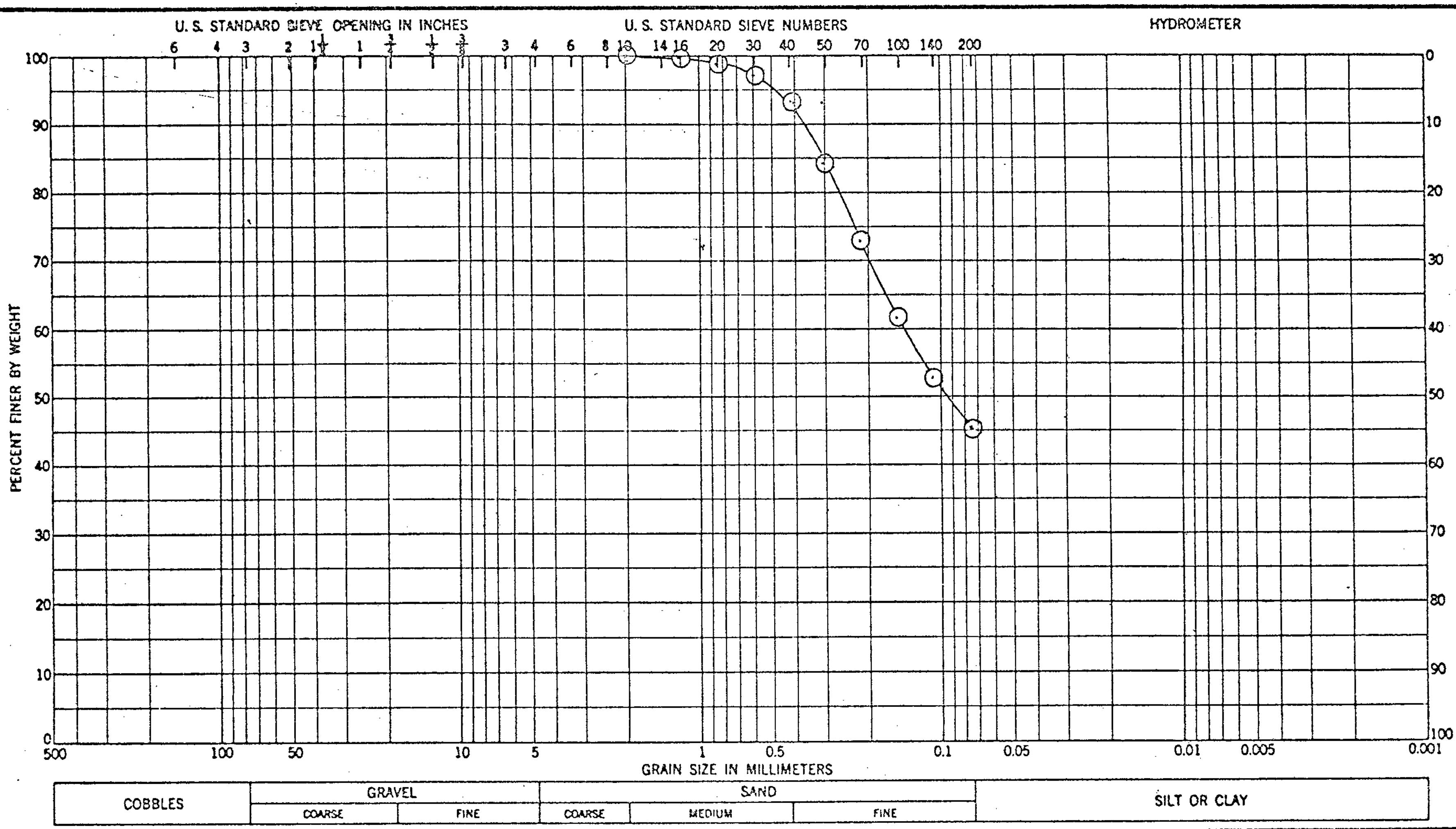
Boring No. 482

Date: 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 5



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	10.0-11.5	SILTY CLAYEY SAND(SC) BROWN Gs= 2.70	13.4	25	18	7

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

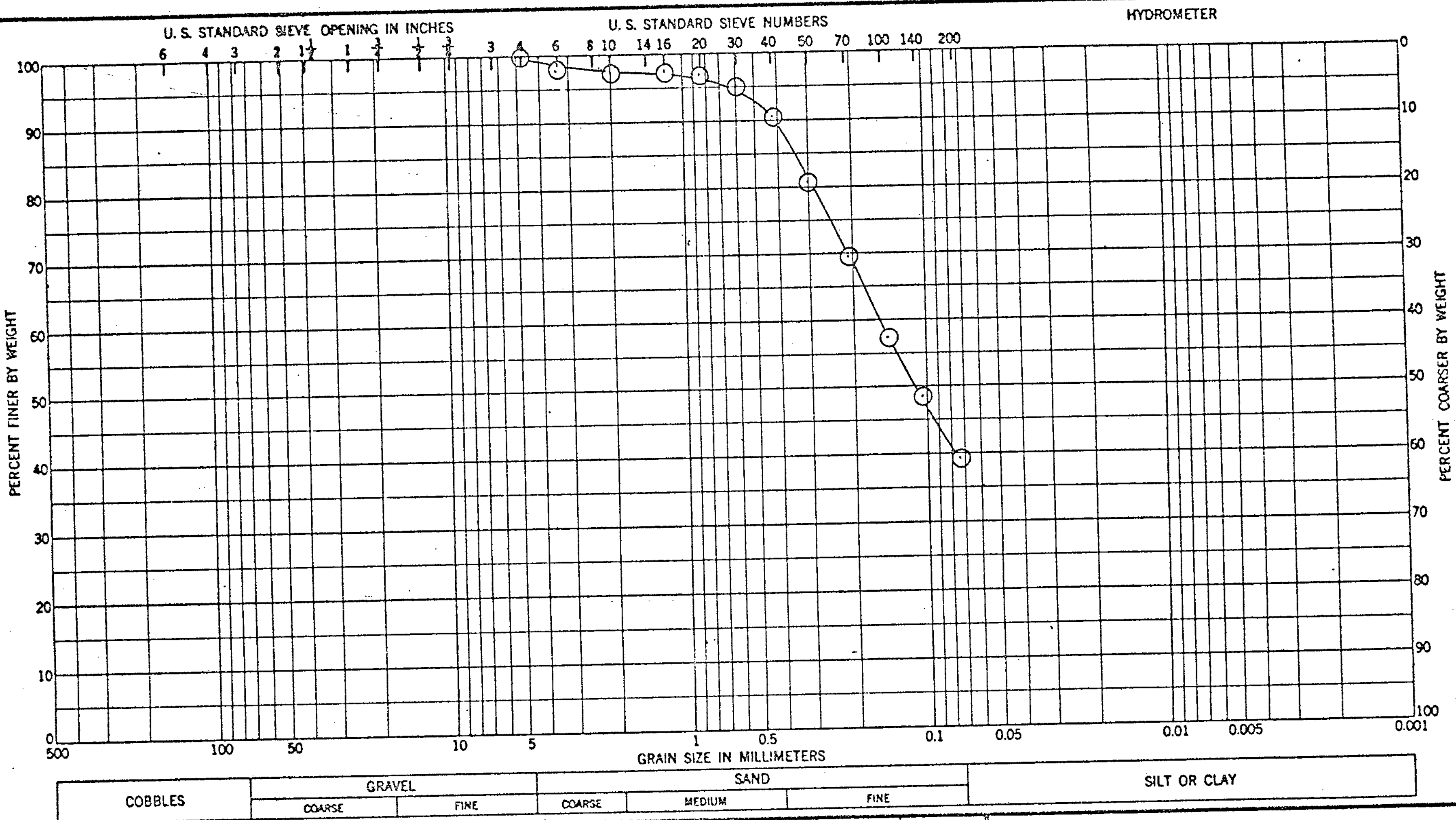
Boring No. 482

Date 30 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 6



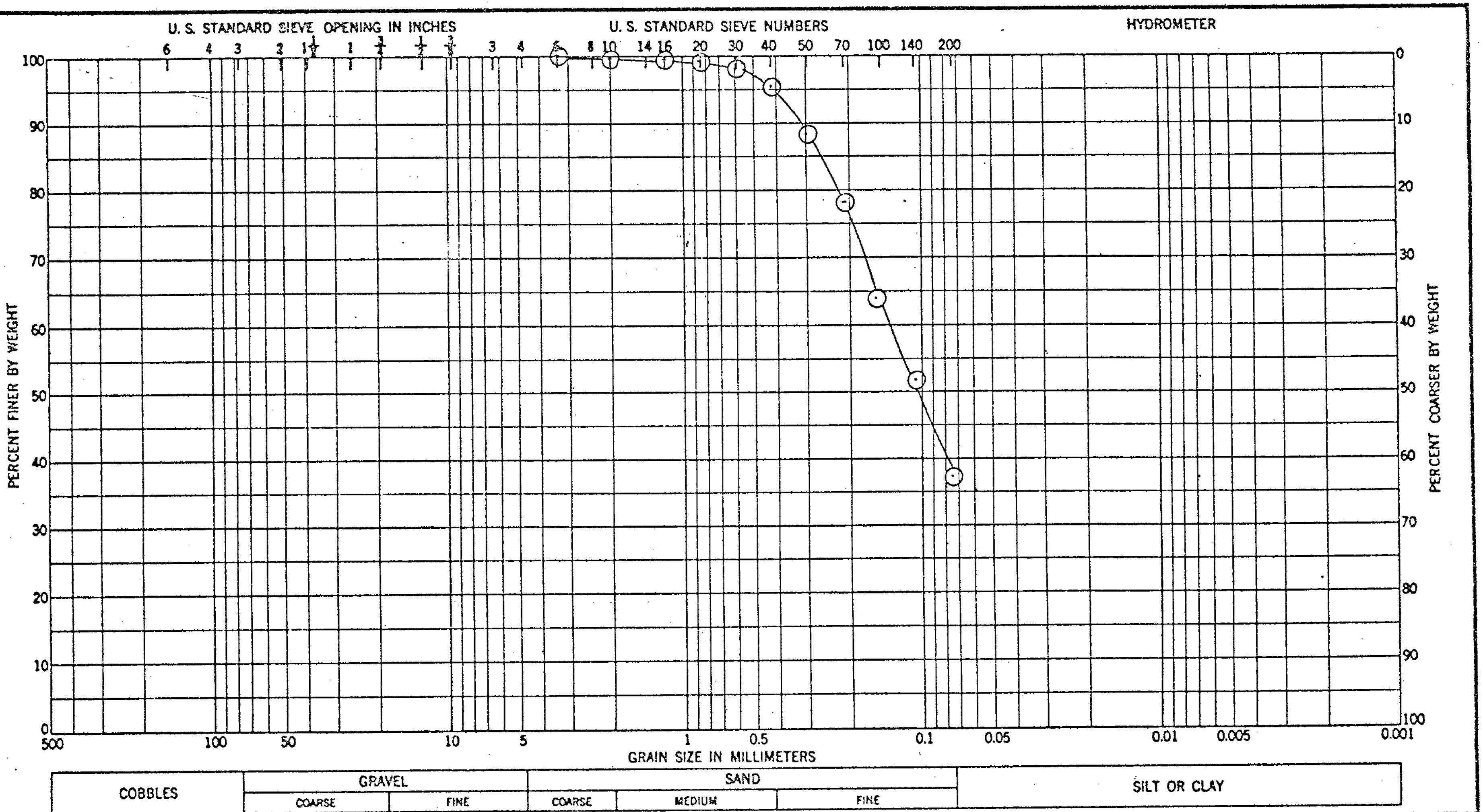
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	12.5-14.0	CLAYEY SAND(SC) BROWN Gs= 2.69	12.4	23	10	13

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	482
Date	28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 7



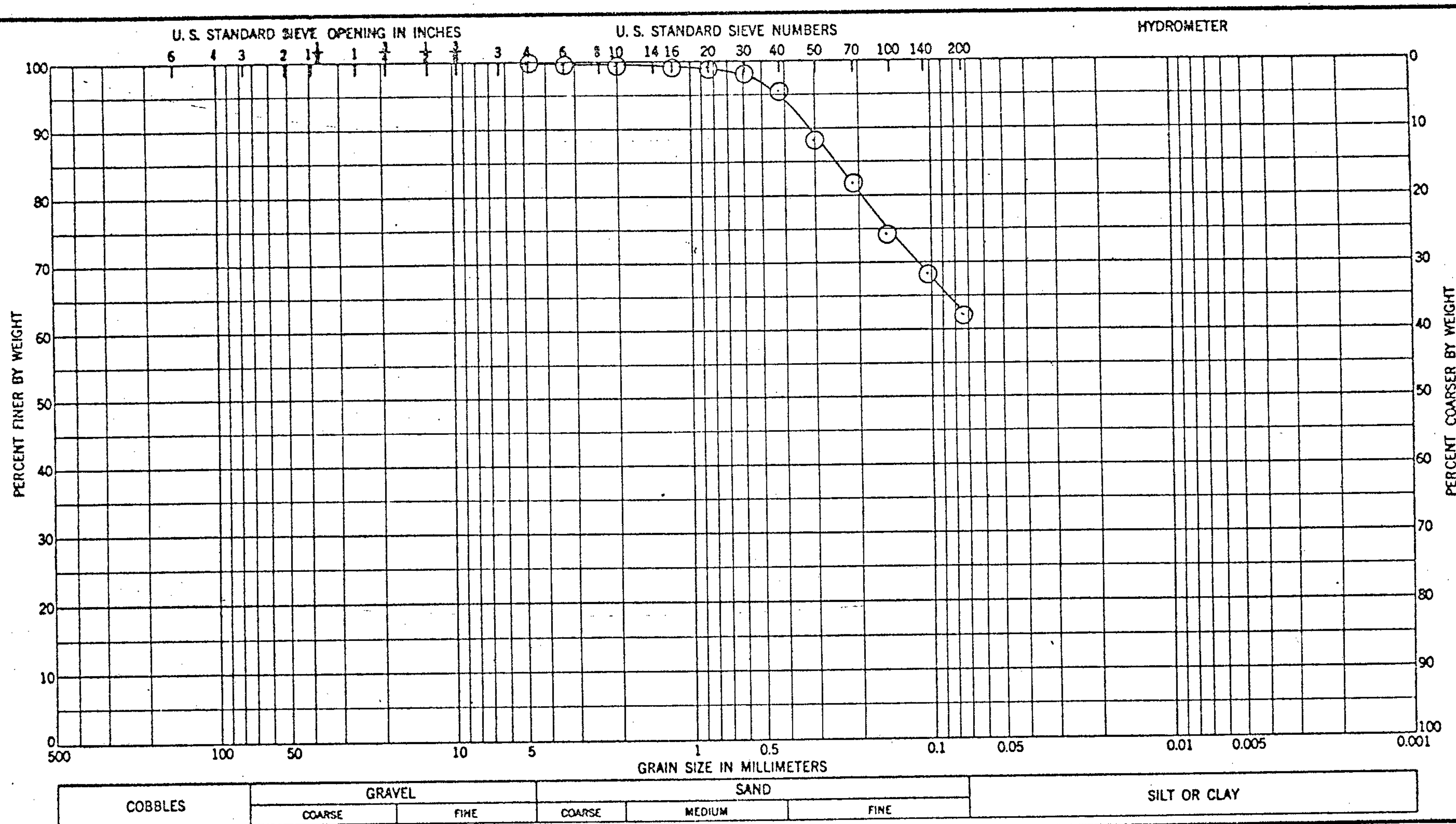
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
7	15.0-16.5	SILTY SAND(SM) BROWN Gs= 2.70	8.2	NP		

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	482
Date	28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 8



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
8	19.0-20.5	SANDY CLAY(CL) BROWN	7.4	28	19	9
		Gs= 2.72				

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

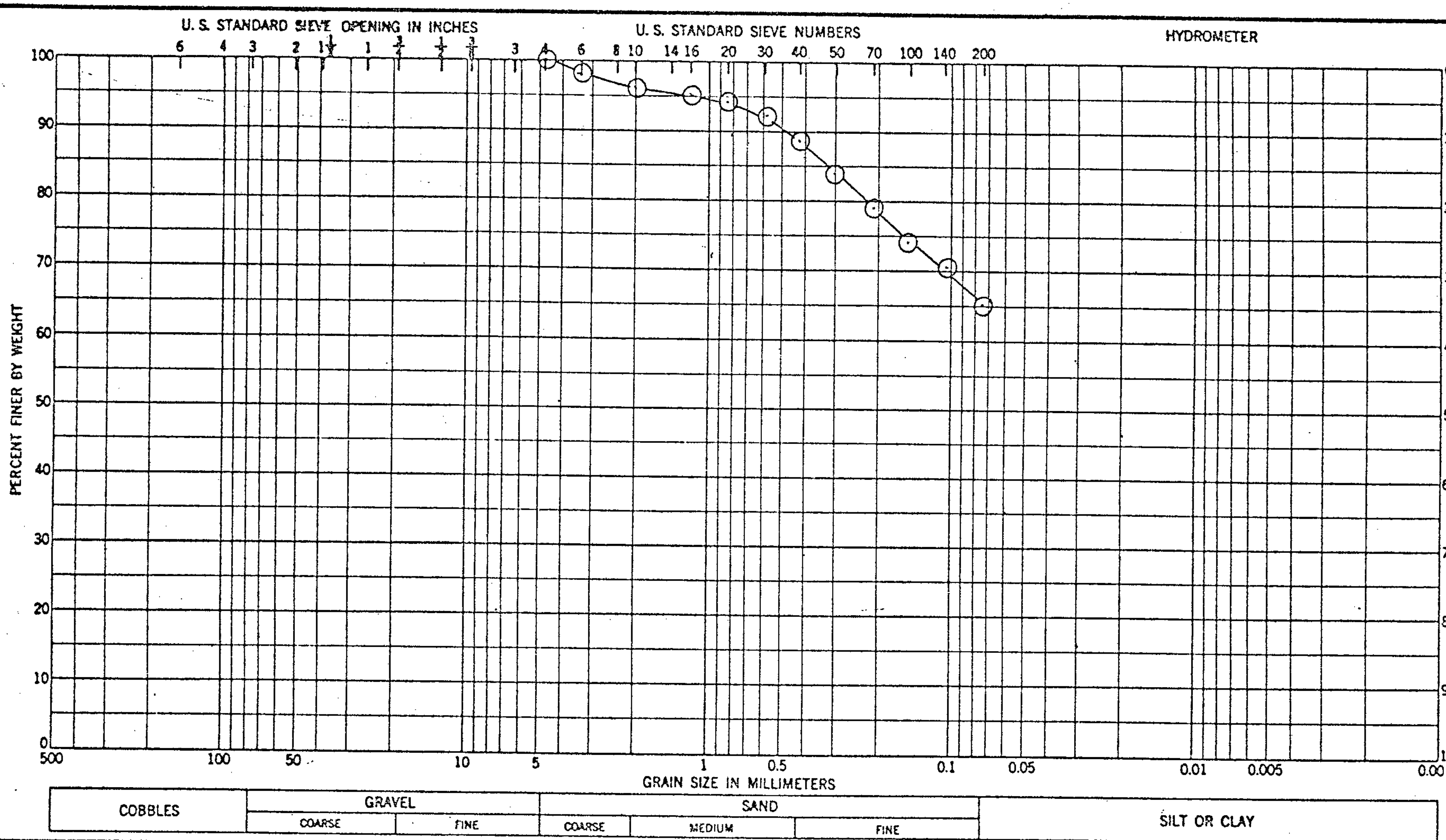
Boring No. 482

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 9



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
9	22.5-24.0	SANDY CLAY(CL) BROWN Gs= 2.73	9.0	36	15	21

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

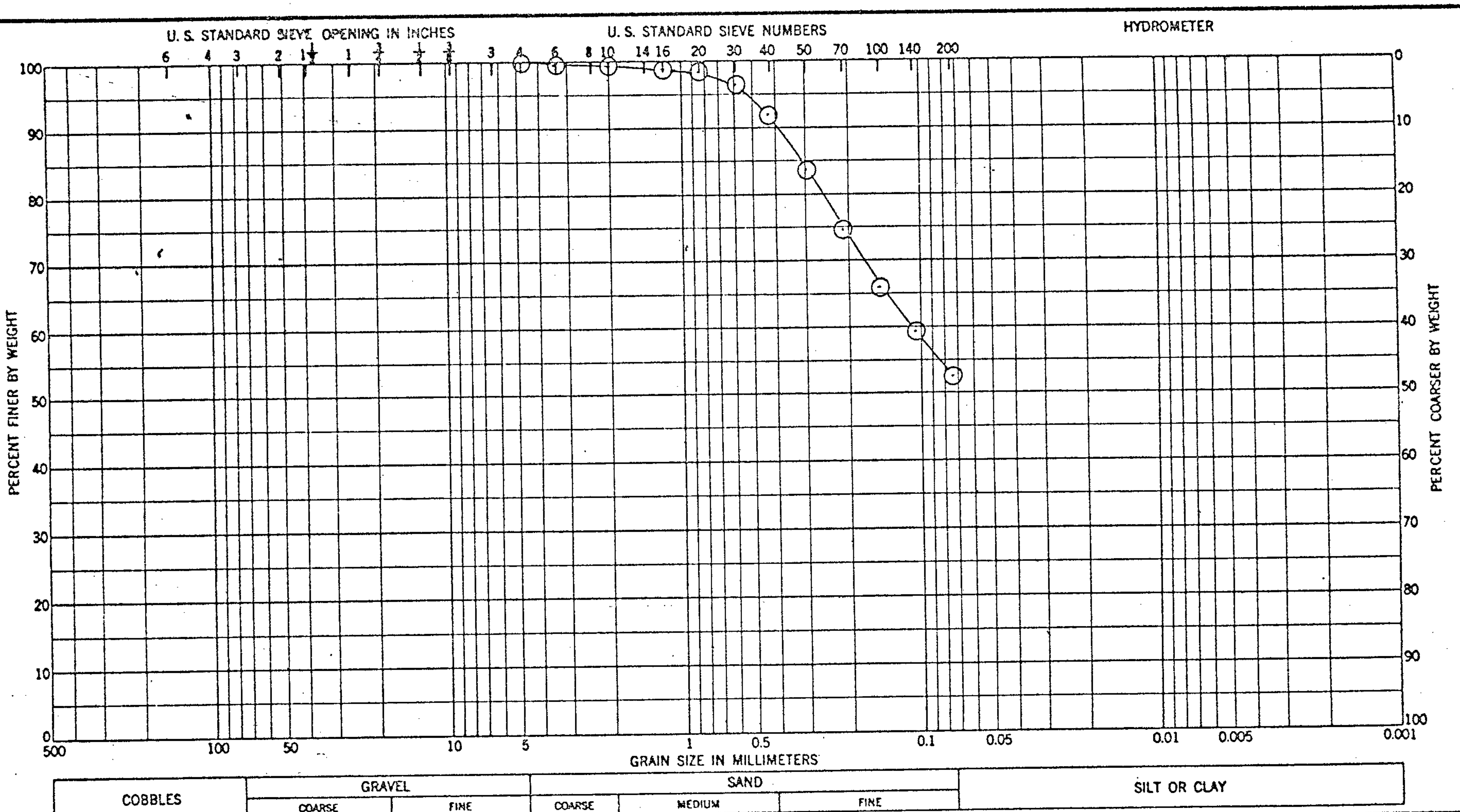
Boring No. 482

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 10



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
10	24.5-26.0	SANDY CLAY(CL) BROWN Gs=2.72	9.8	34	13	21

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

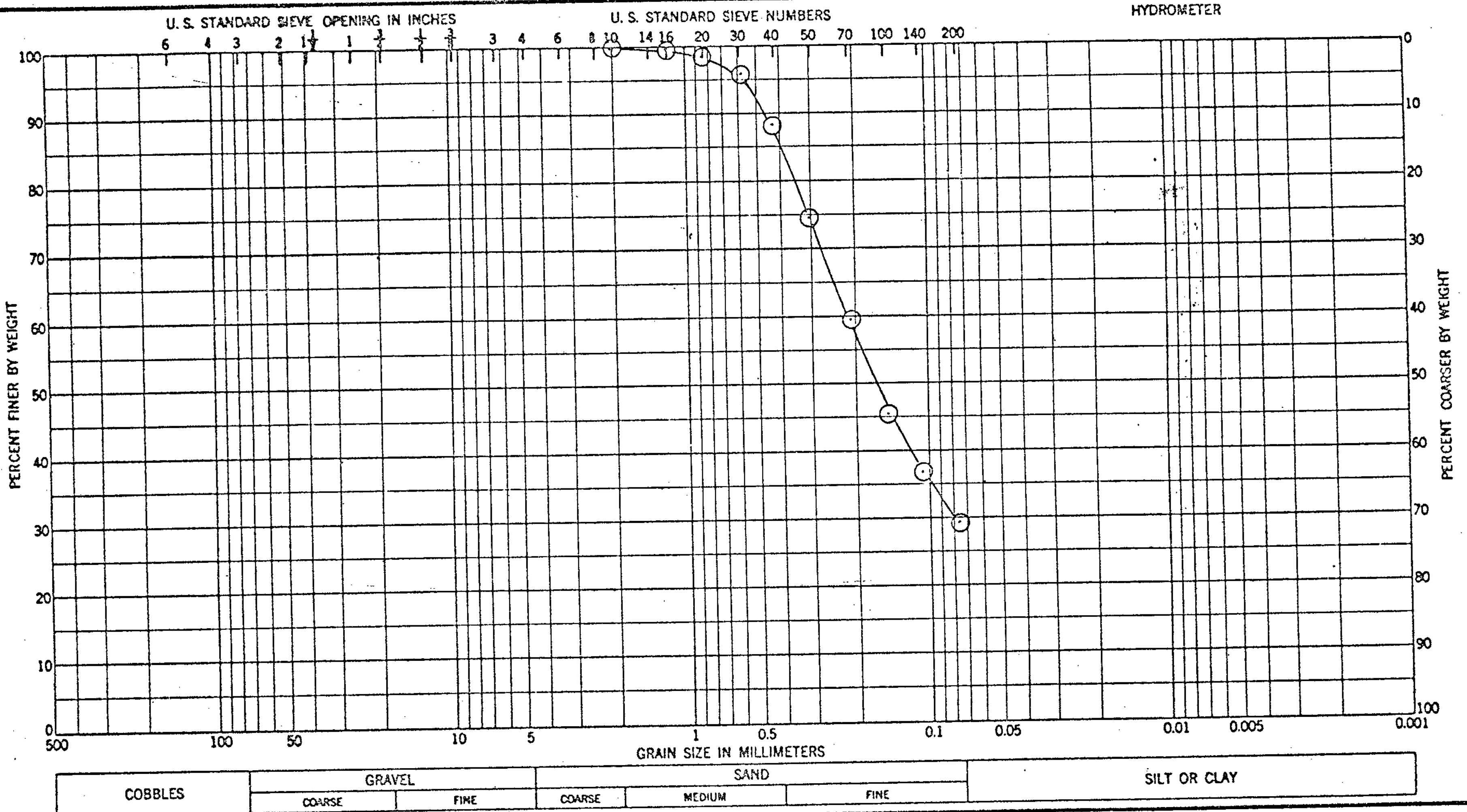
Boring No. 482

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 11



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0-1.5	SILTY SAND(SM) BROWN	9.5	NP		
		Gs= 2.70				

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

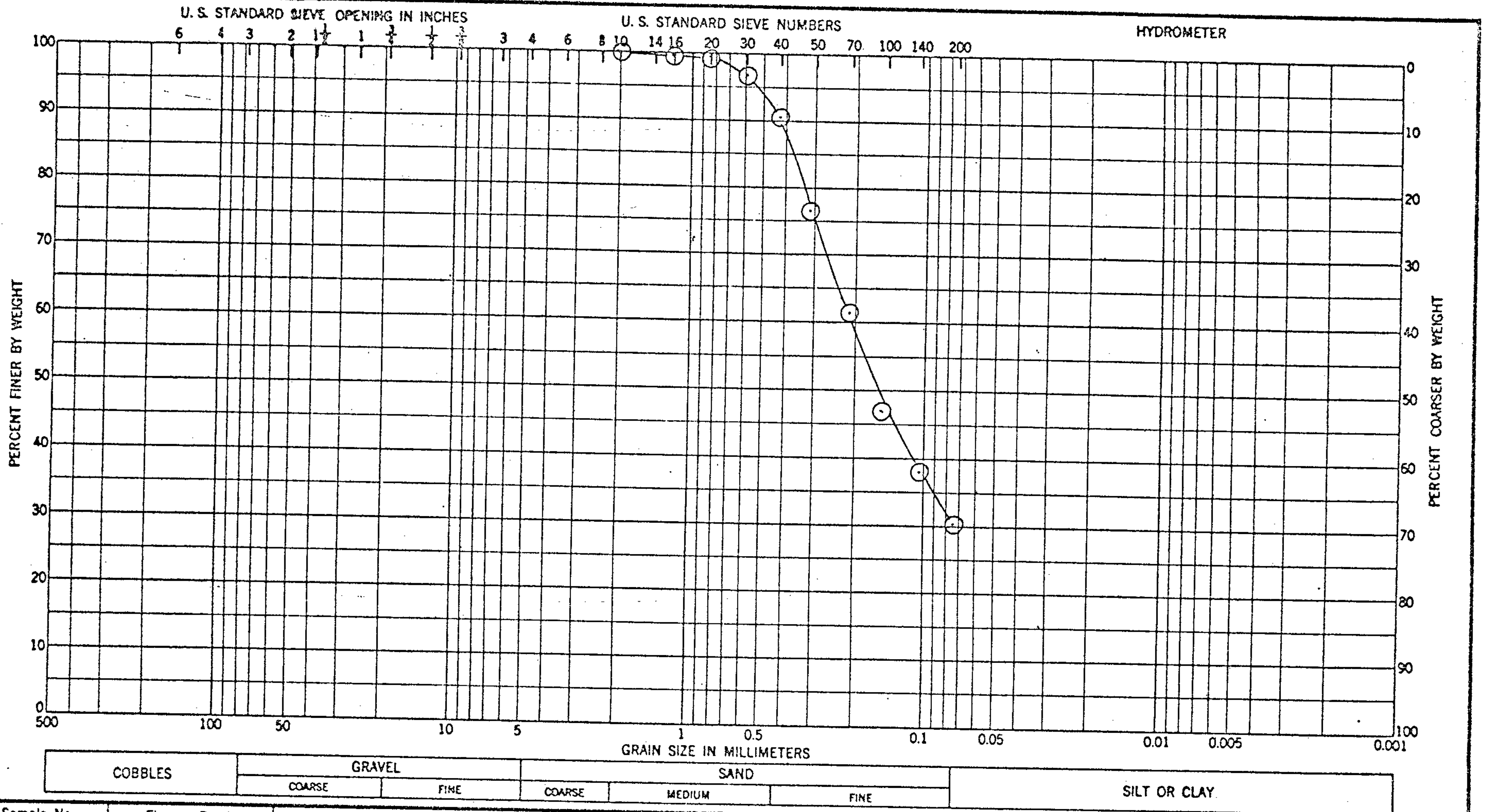
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 12



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	2.5-4.0	SILTY SAND(SM) BROWN Gs= 2.70	9.3	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

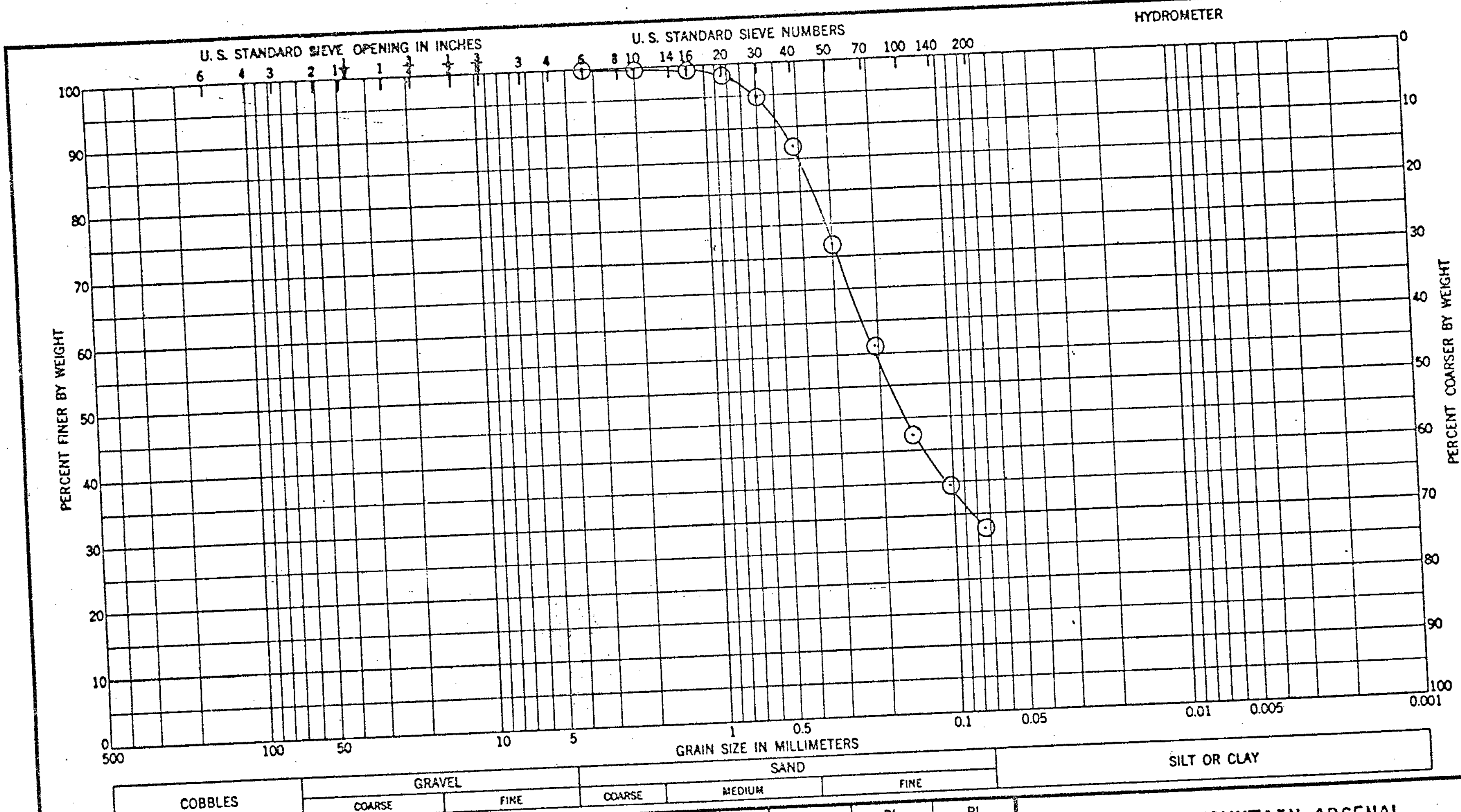
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 13



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	5.0-6.5	SILTY SAND(SM) BROWN Gs= 2.70	9.3	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

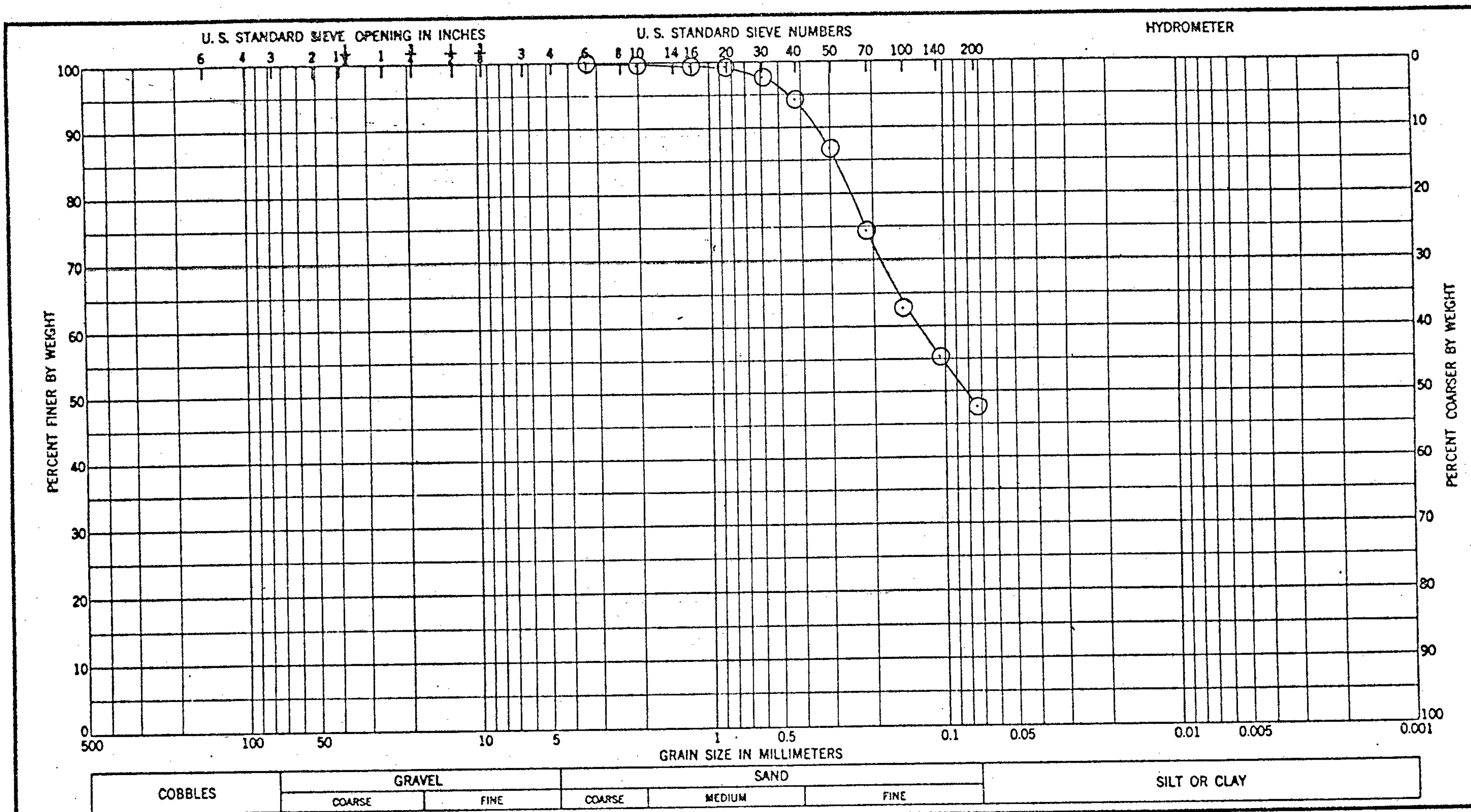
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 2087

Figure 14



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	7.5-8.7	CLAYEY SAND(SC) DARK BROWN Gs=2.68	12.2	26	15	11

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

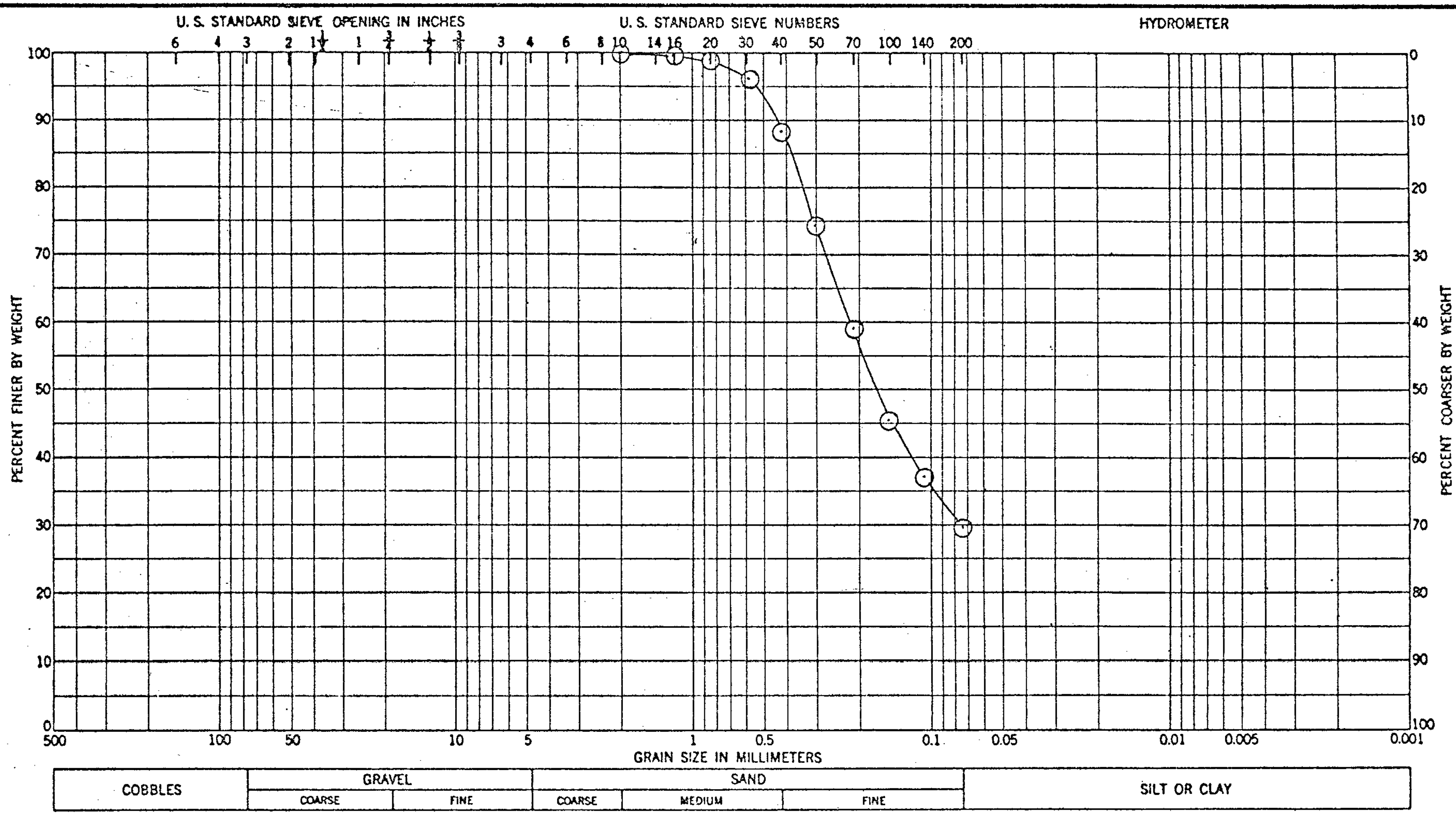
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 15



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	10.0-11.3	CLAYEY SAND(SC) BROWN Gs= 2,70	8.3	21	14	7

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

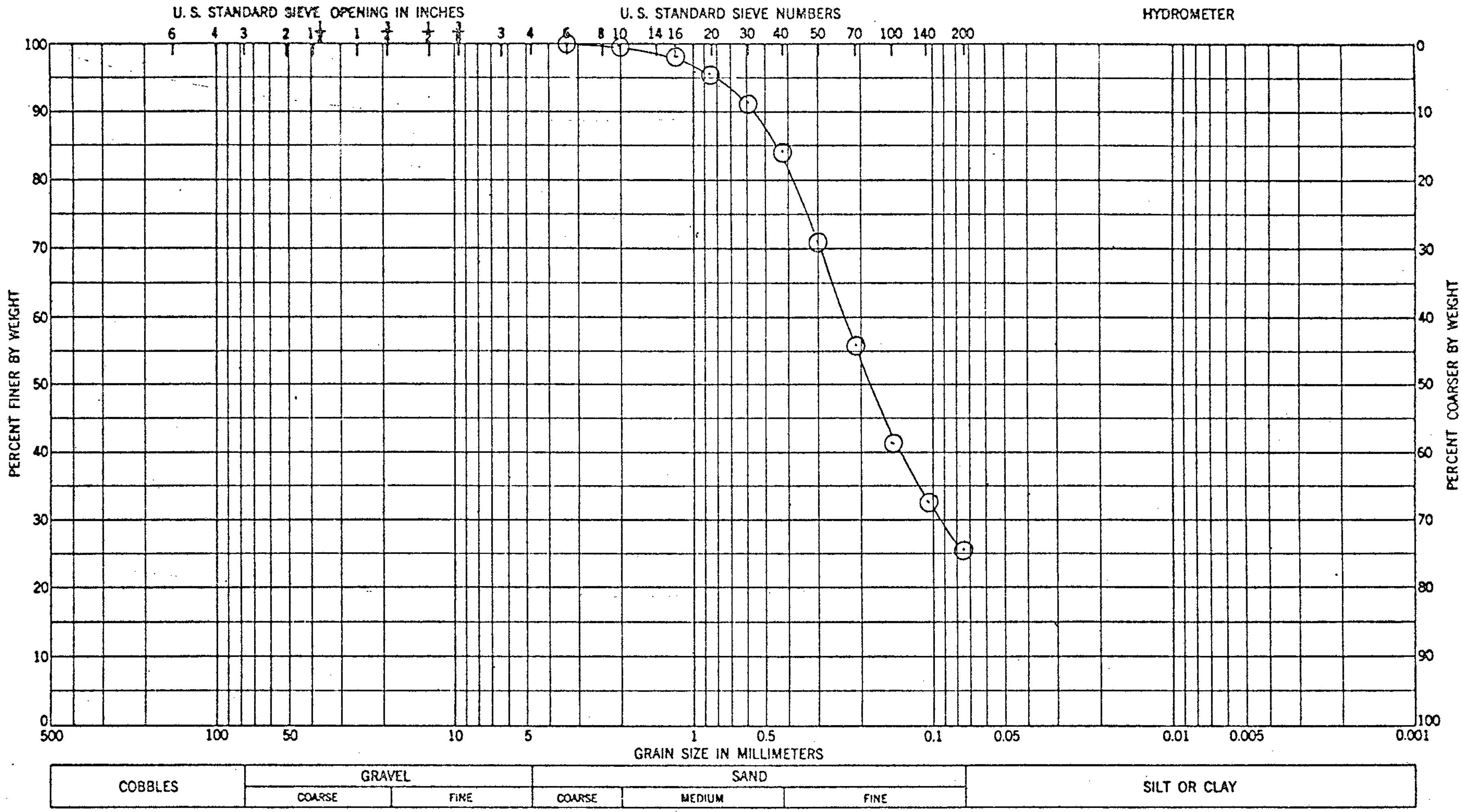
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 16



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	12.5-13.7	SILTY SAND(SM) BROWN	10.5	NP		
		Gs= 2.69				

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

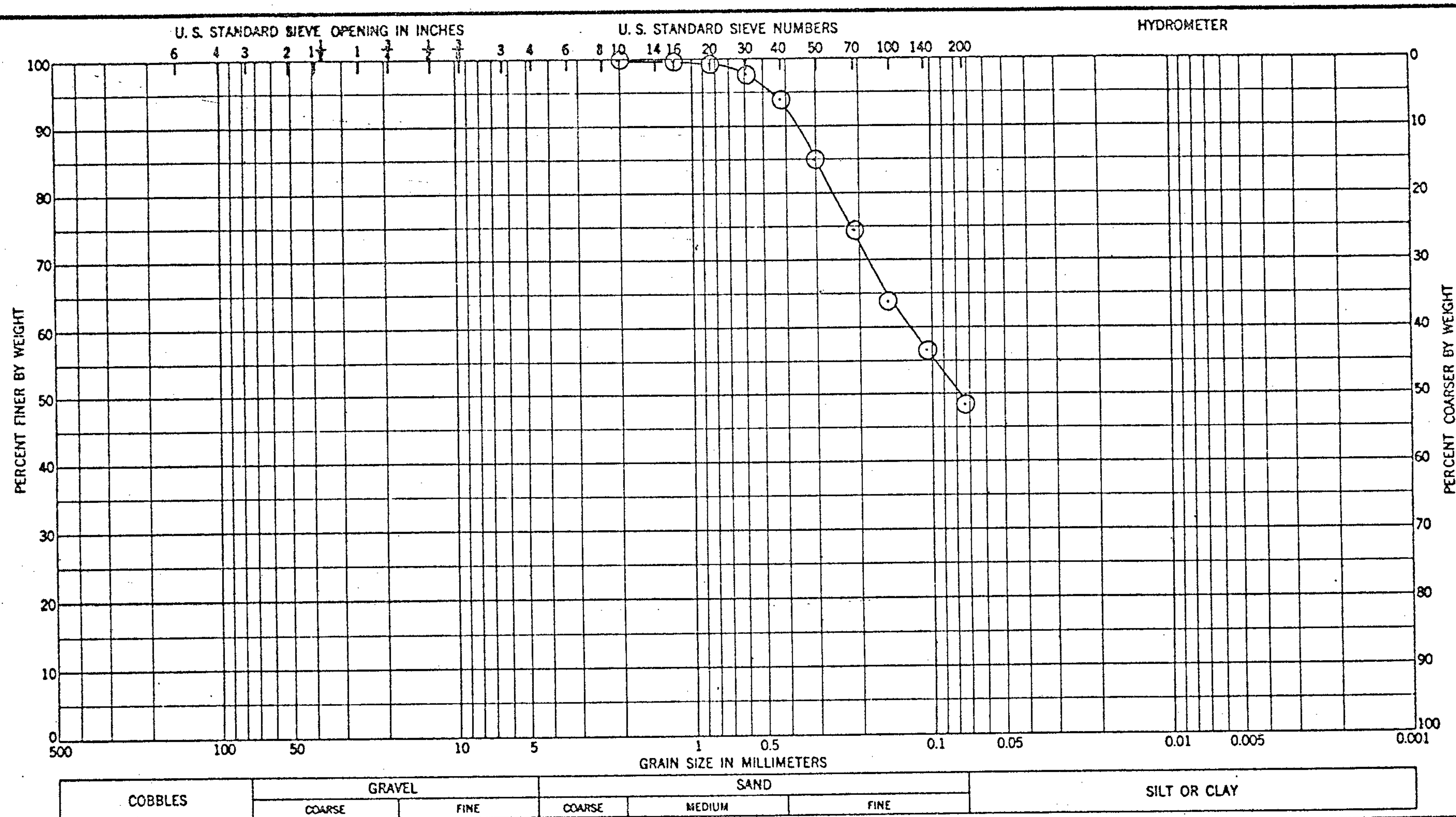
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 17



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
7	15.0-16.5	CLAYEY SAND(SC) BROWN	8.8	24	13	11
		Gs= 2.71				

Project ROCKY MOUNTAIN ARSENAL

Area E BASIN - DIKE

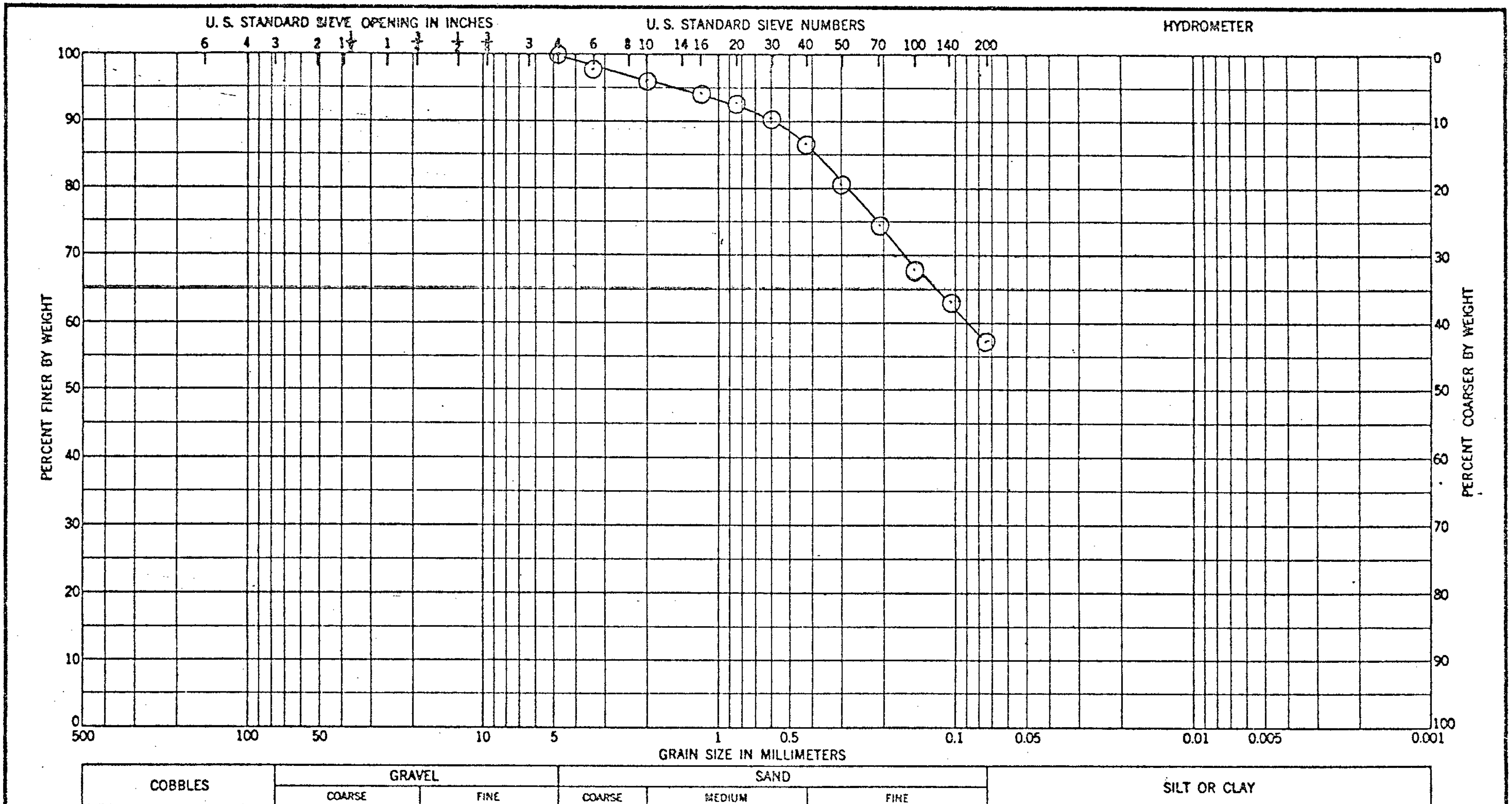
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 18



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
8	17.5-18.6	SANDY CLAY(CL) TAN Gs=2.72	9.1	34	13	21

Project ROCKY MOUNTAIN ARSENAL

Area E. BASIN - DIKE

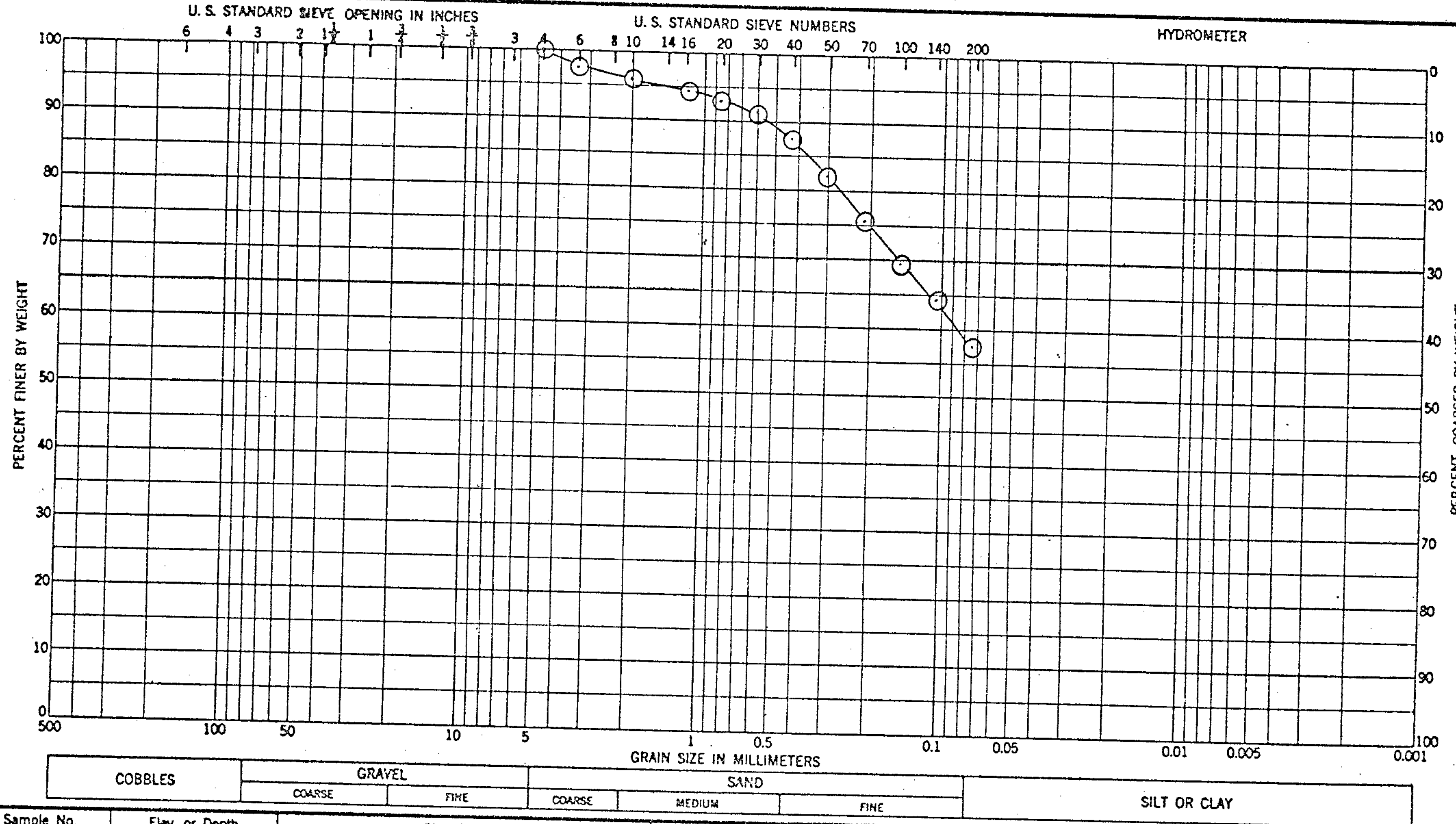
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 19



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
9	20.0-21.4	SANDY CLAY(CL) BROWN Gs= 2.73	8.6	29	13	16

GRADATION CURVES

Project ROCKY MOUNTAIN ARSENAL

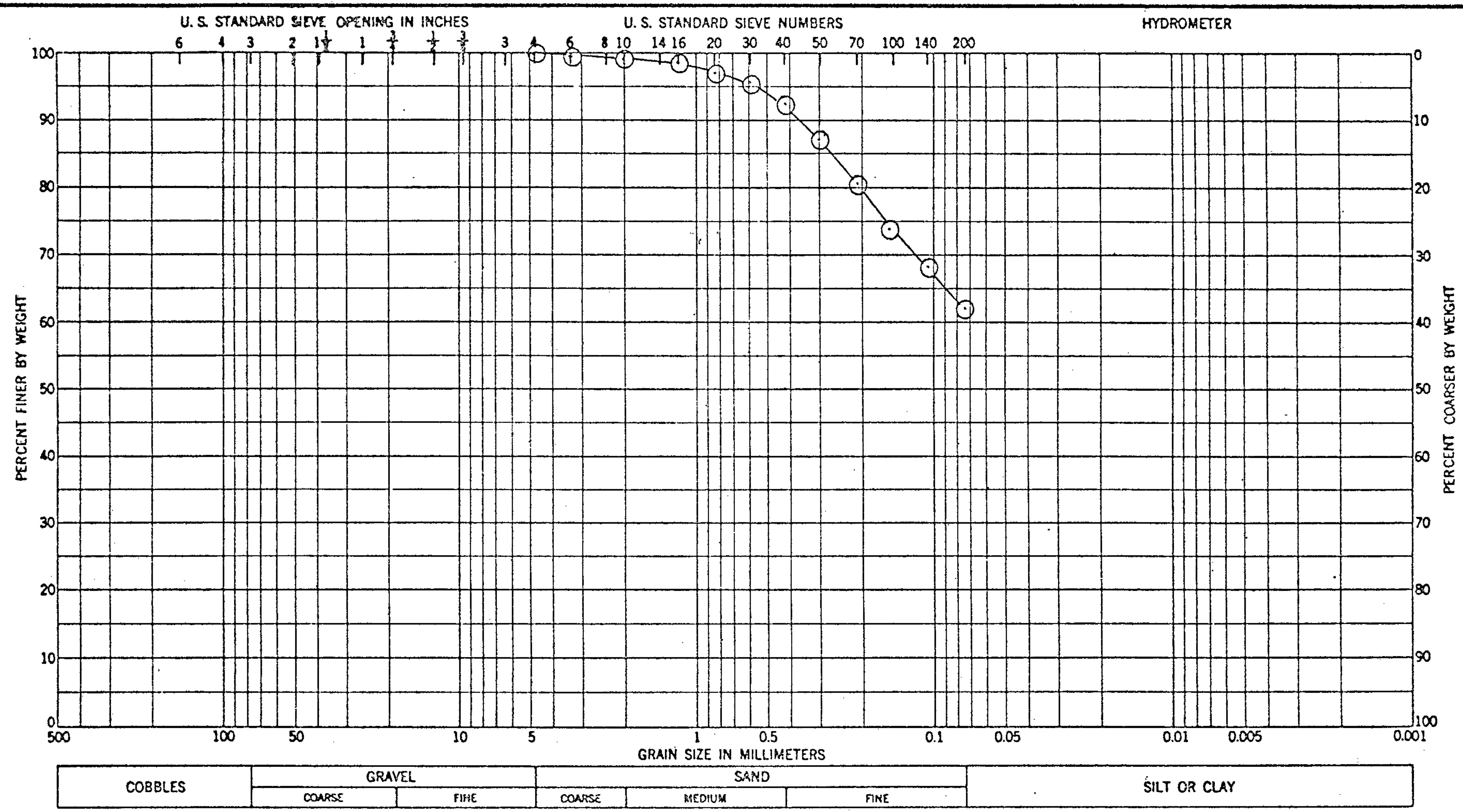
Area F BASIN - DIKE

Boring No. 483

Date 28 DEC 77

ENG FORM 1 MAY 63 2087

Figure 20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
10	22.5-23.7	SANDY CLAY (CL) BROWN	9.5	35	14	21
		Gs= 2.74				

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

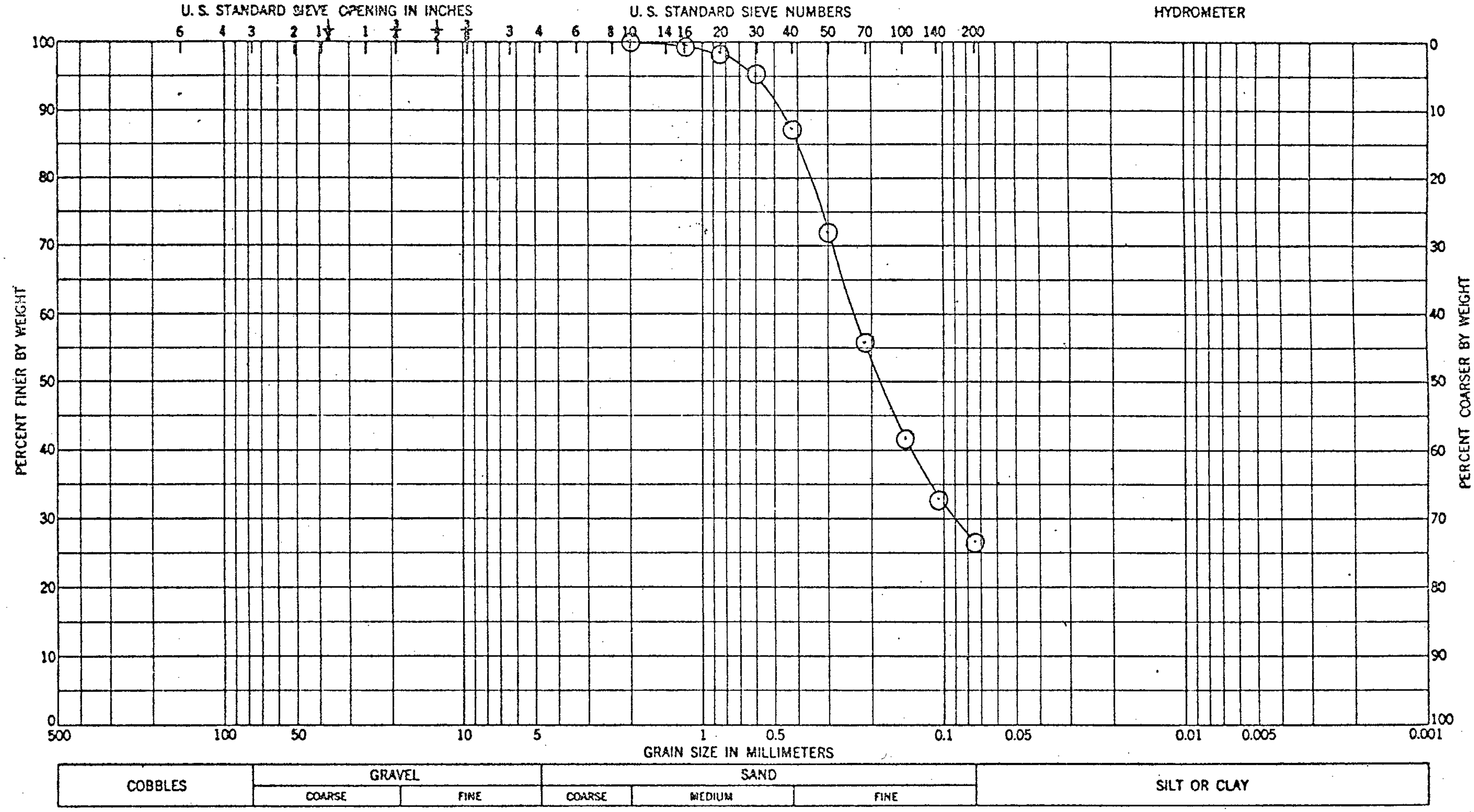
Boring No. 483

Date 28 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 21



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0.0-1.3	SILTY SAND(SM) BROWN	9.3	NP		
		Gs= 2.69				

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

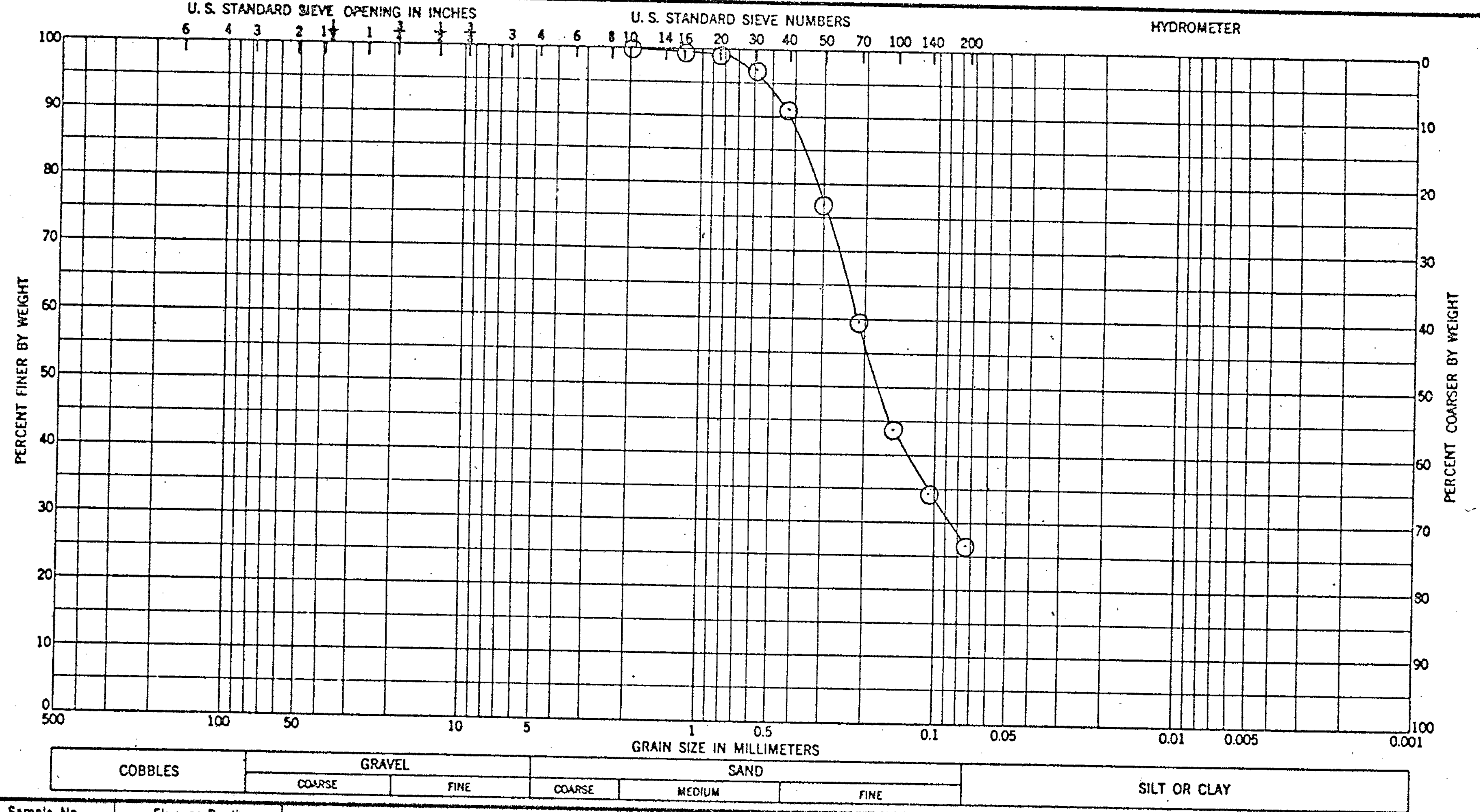
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 22



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	2.5-3.9	SILTY SAND(SM) BROWN Gs= 2.70	13.1	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

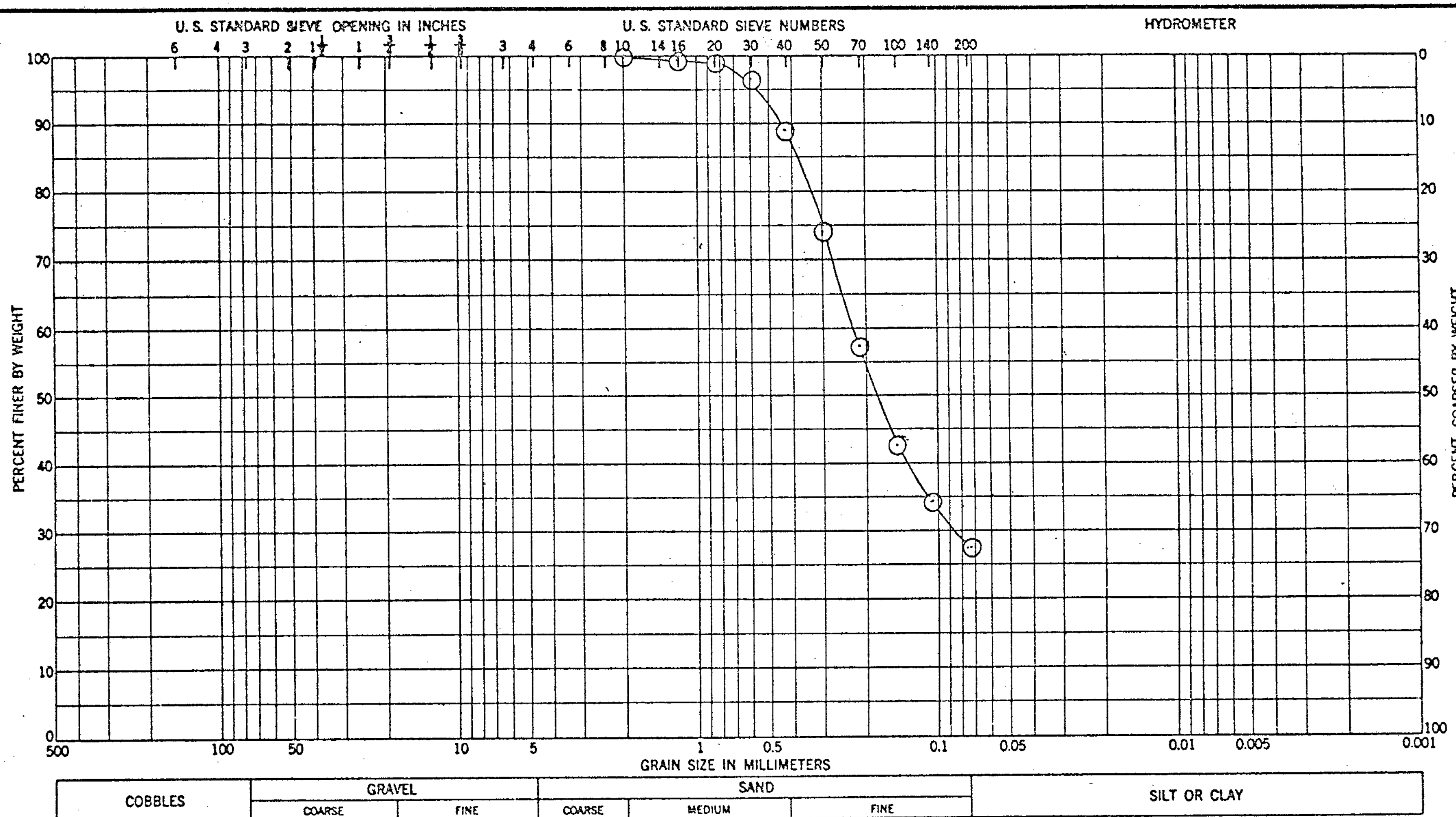
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 23



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	5.0-6.3	SILTY SAND(SM) BROWN Gs= 2.69	12.3	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

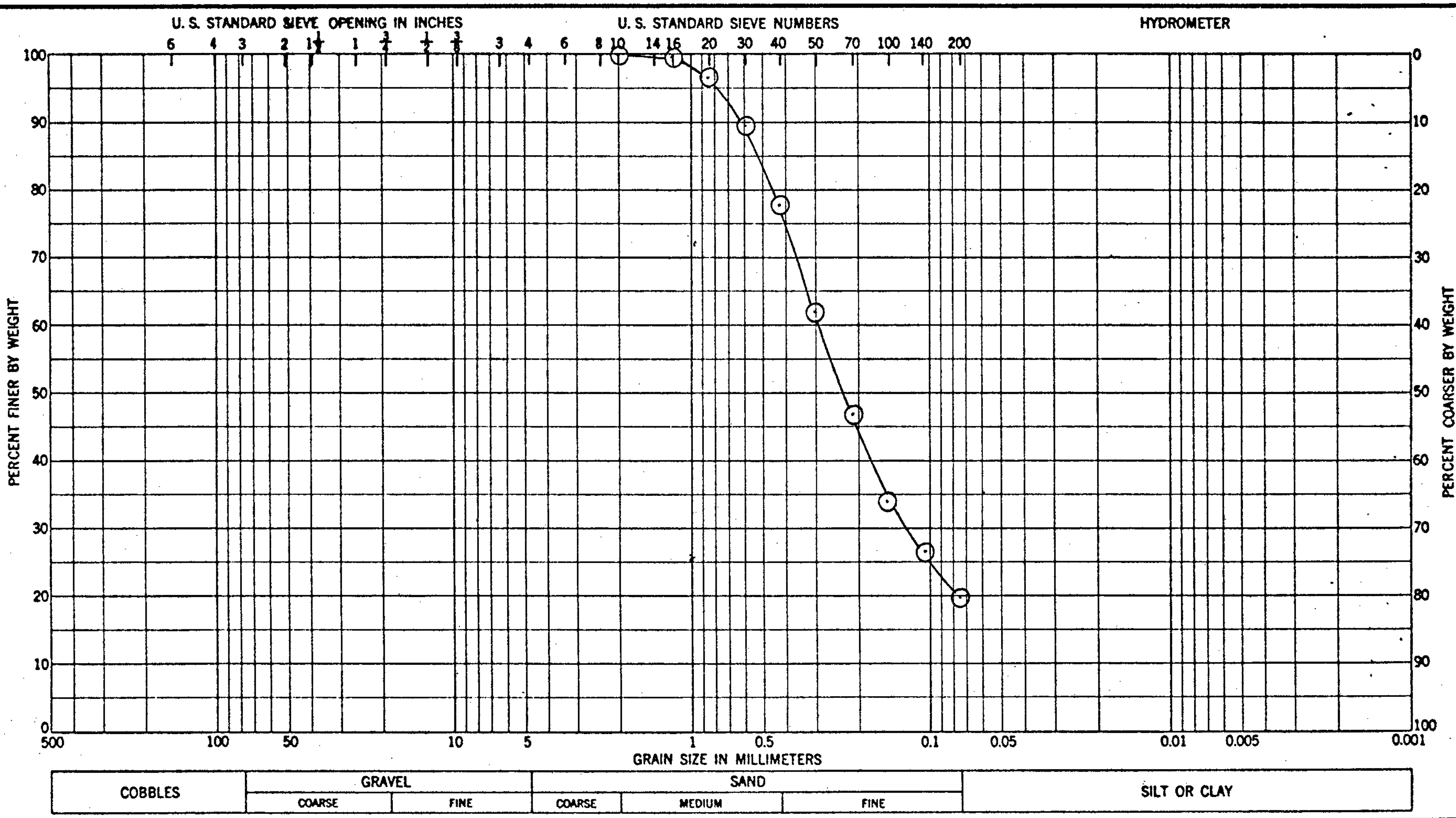
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 24



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	7.5-8.9	SILTY SAND(SM) BROWN Gs= 2.70	7.4	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

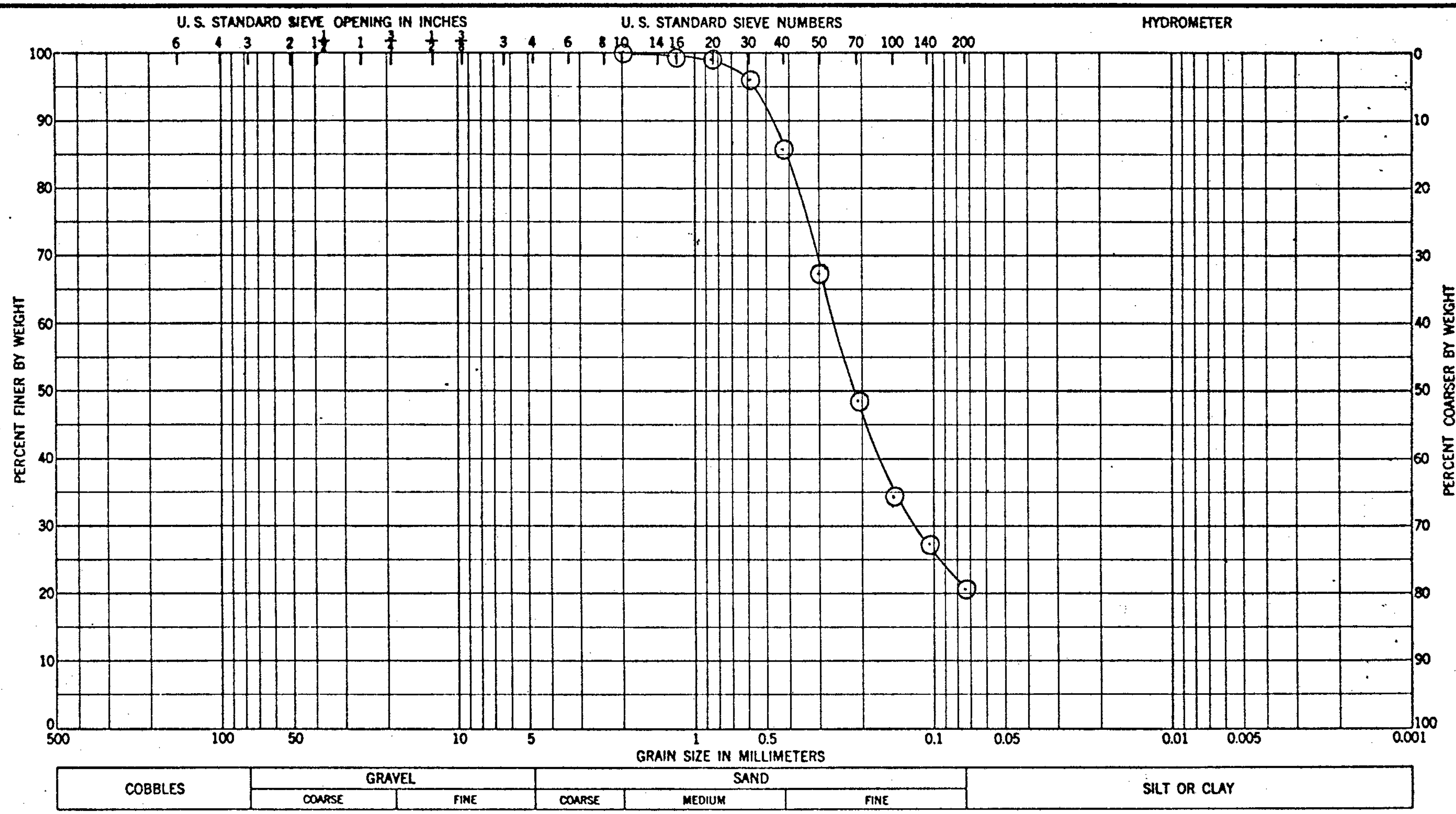
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 25



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	10.0-11.5	SILTY SAND(SM) BROWN Gs= 2.70	6.4	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

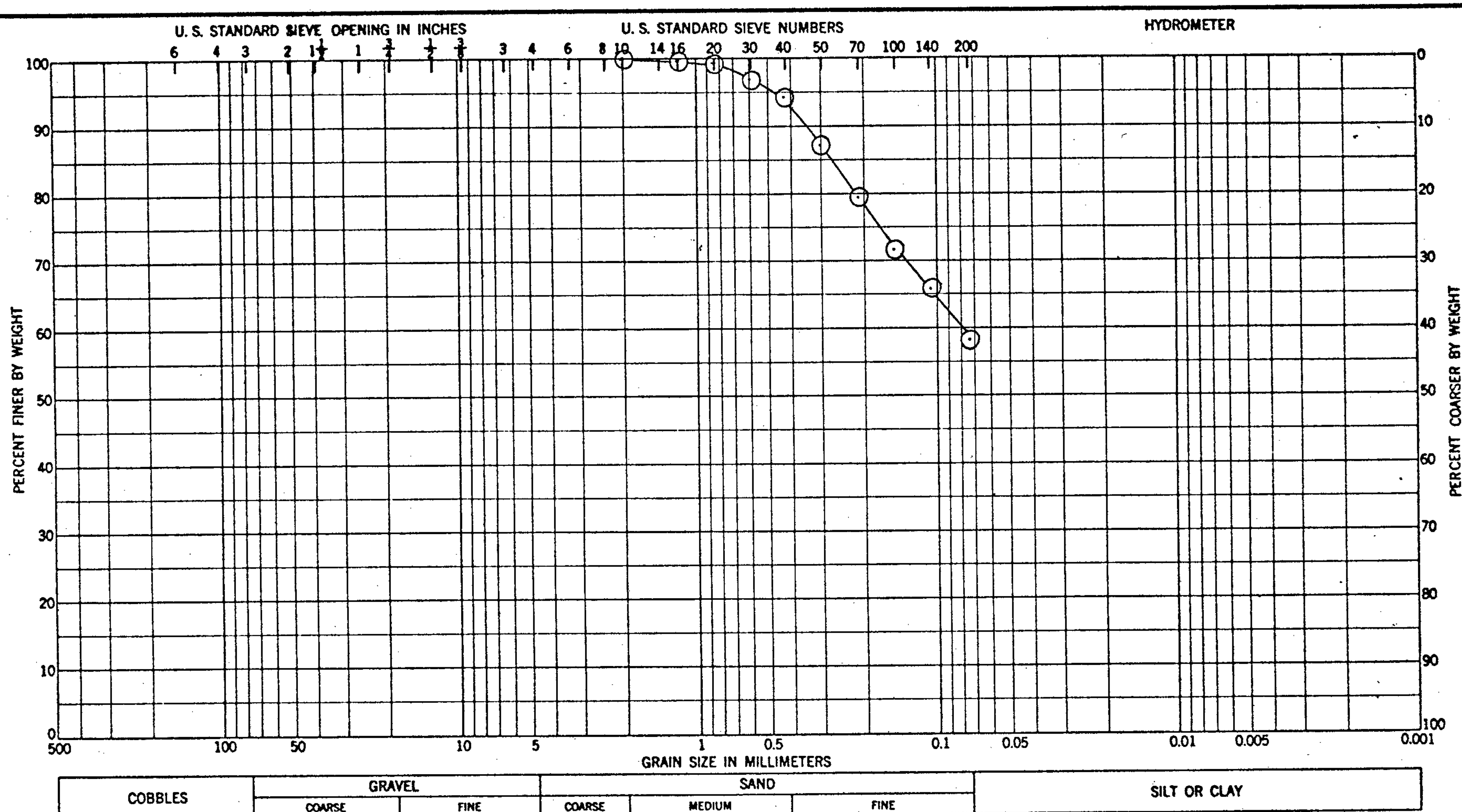
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 26



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	12.5-13.7	SANDY CLAY(CL) BROWN Gs= 2.72	14.2	28	14	14

GRADATION CURVES

Project ROCKY MOUNTAIN ARSENAL

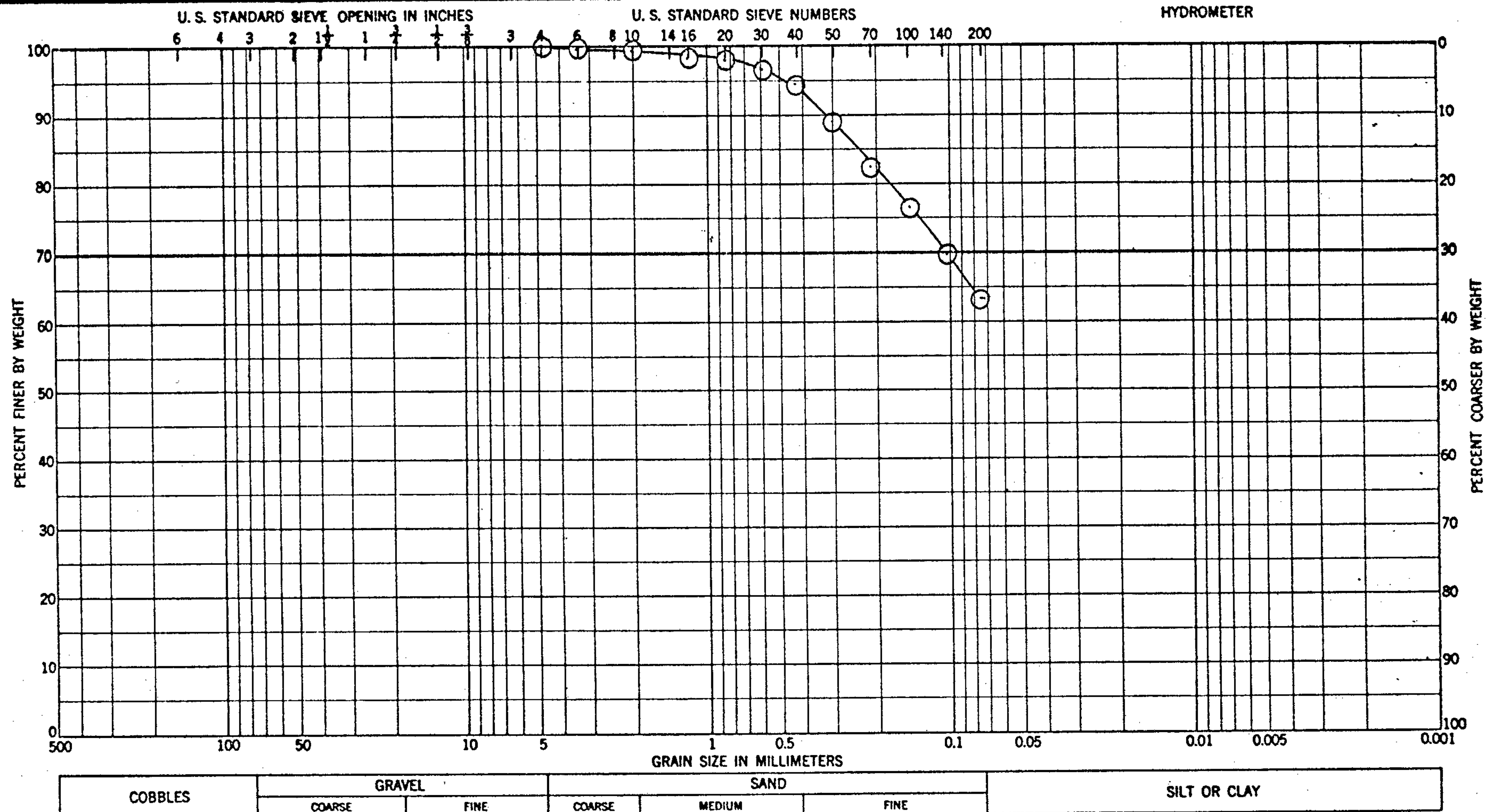
Area F BASIN - DIKE

Boring No. 484

Date 29 DEC 77

ENG FORM 1 MAY 63 2087

Figure 27



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
7	15.0-16.0	SANDY CLAY(CL) BROWN Gs= 2.74	14.8	35	15	20

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

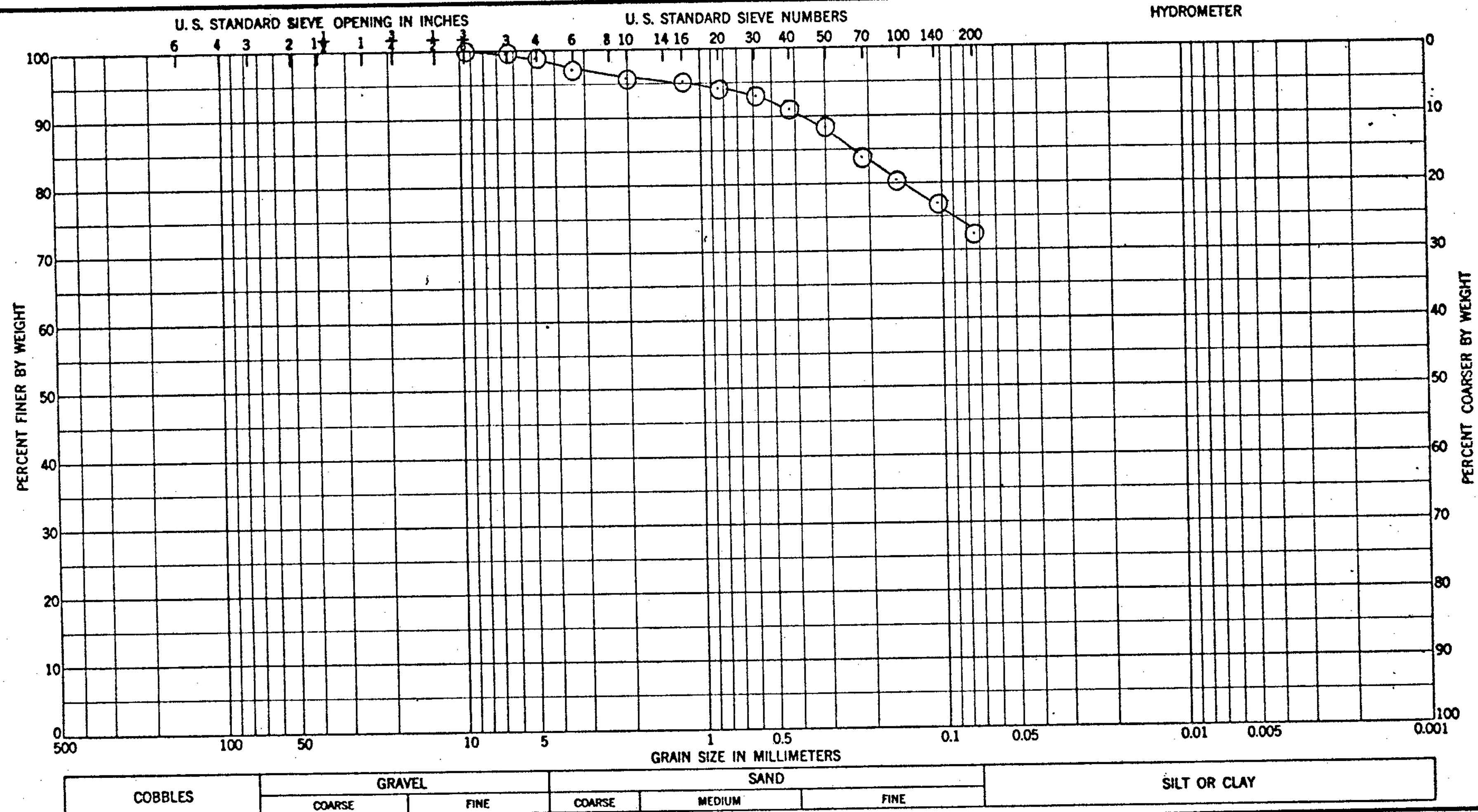
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 28



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
8	17.5-18.8	SANDY CLAY(CL) TAN Gs=2.74	17.8	35	14	21

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

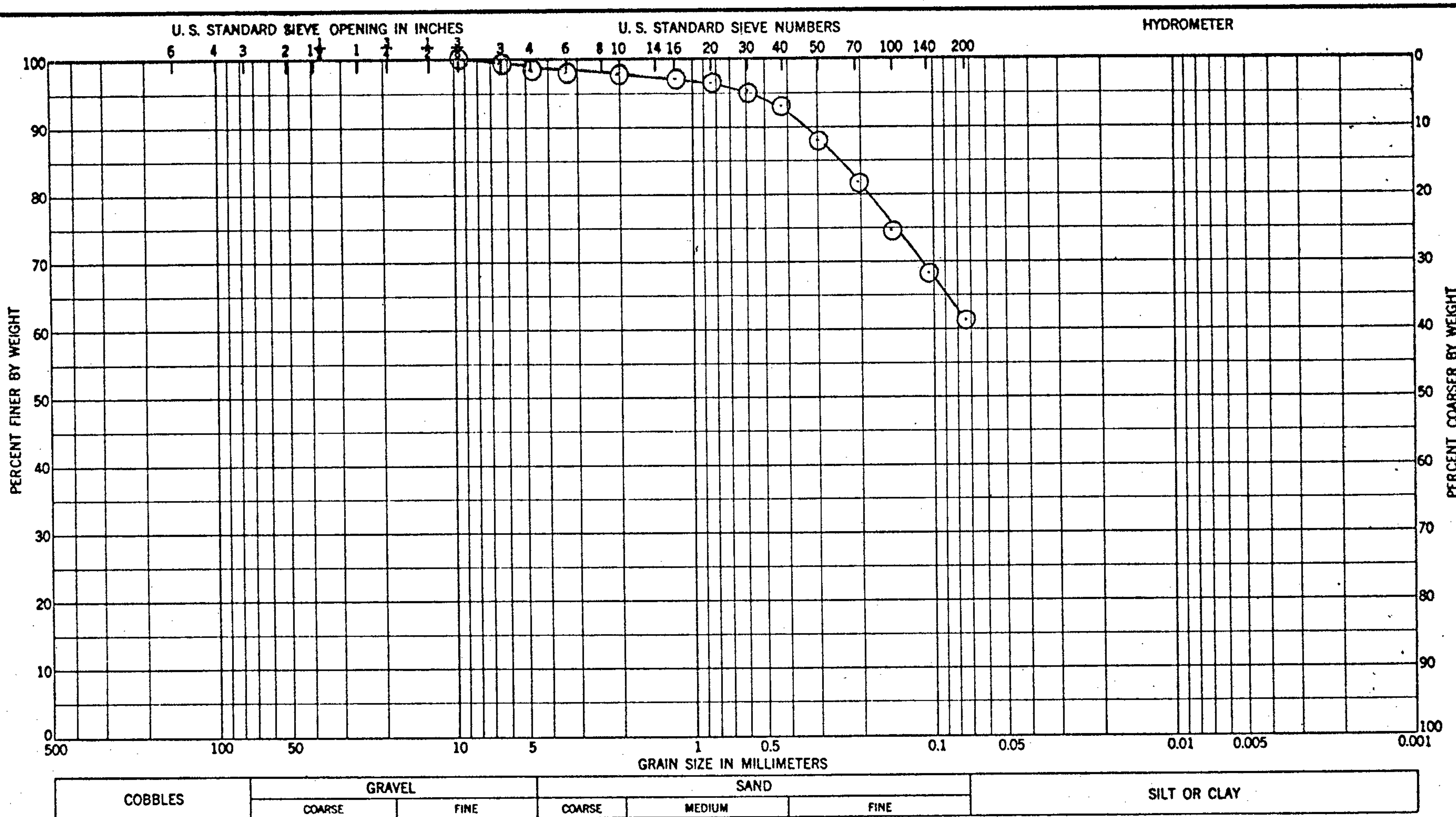
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

Figure 29

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
9	20.0-21.4	SANDY CLAY(CL) TAN Gs= 2.72	22.4	25	12	13

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

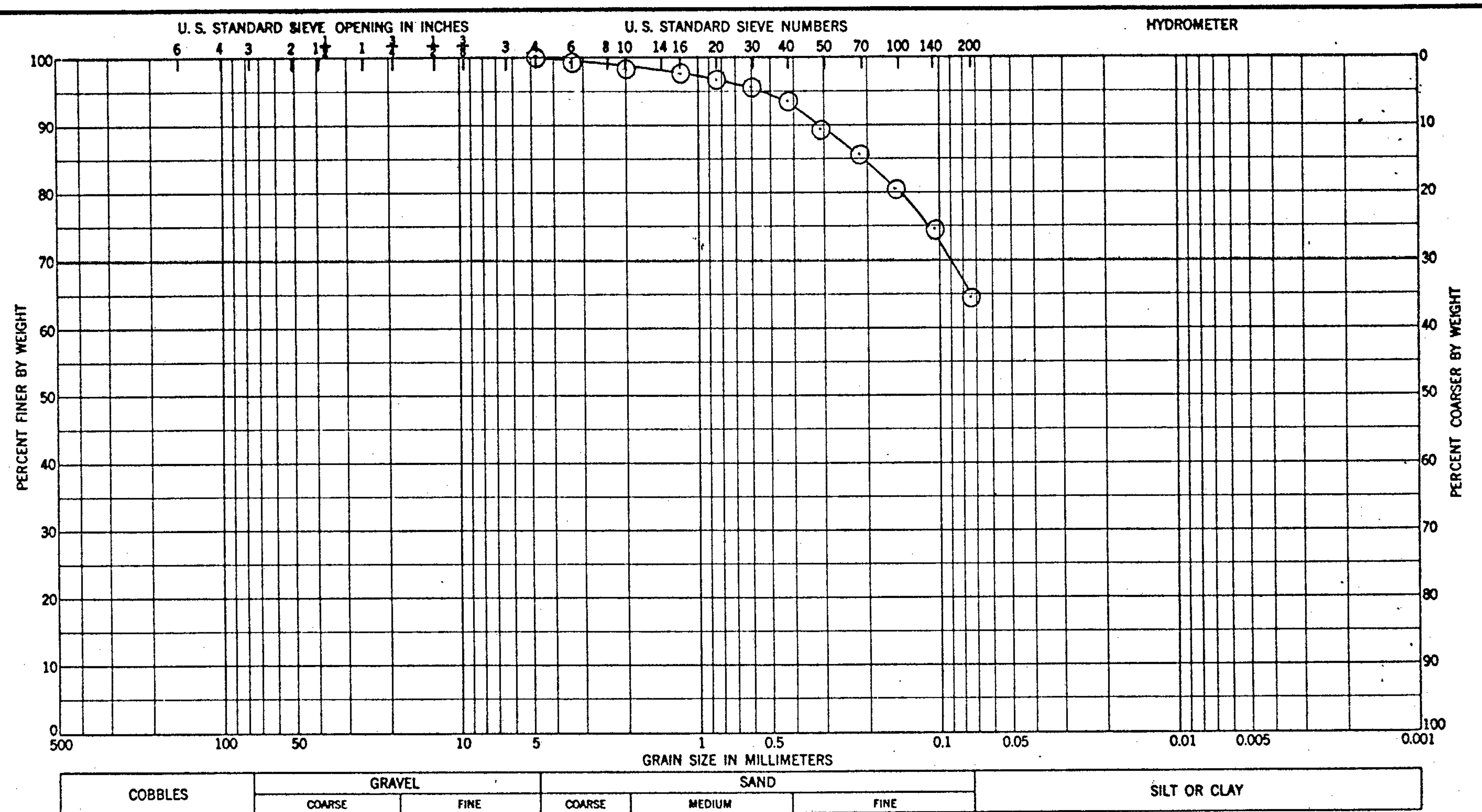
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 30



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
10	22.5-23.9	SANDY CLAY(CL) LIGHT BROWN	17.9	25	17	8
		Gs= 2.73				

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

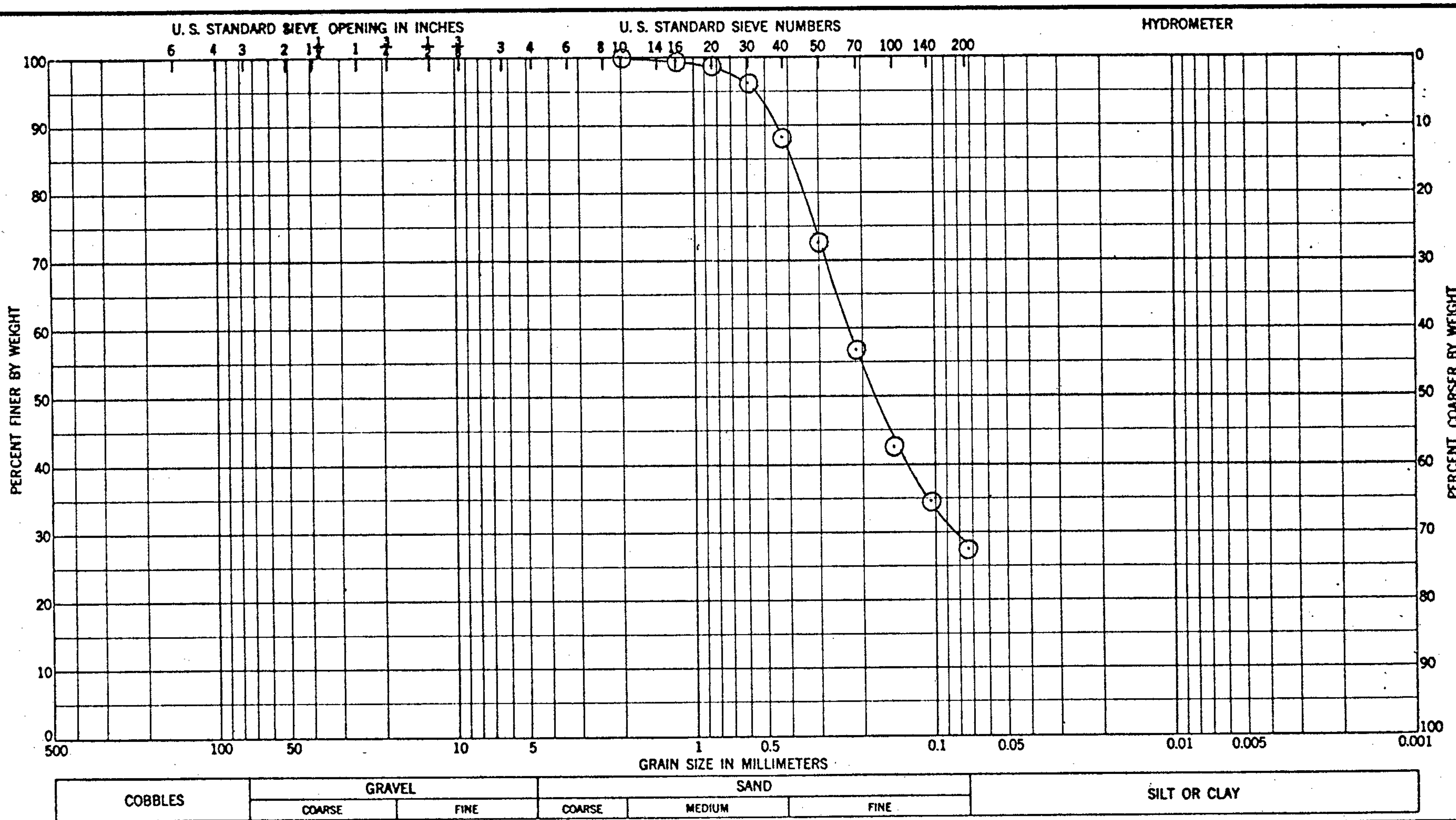
Boring No. 484

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 31



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	0.0-1.2	SILTY SAND(SM) BROWN Gs= 2.70	6.4	NP		

Project: ROCKY MOUNTAIN ARSENAL

Area: F BASIN - DIKE

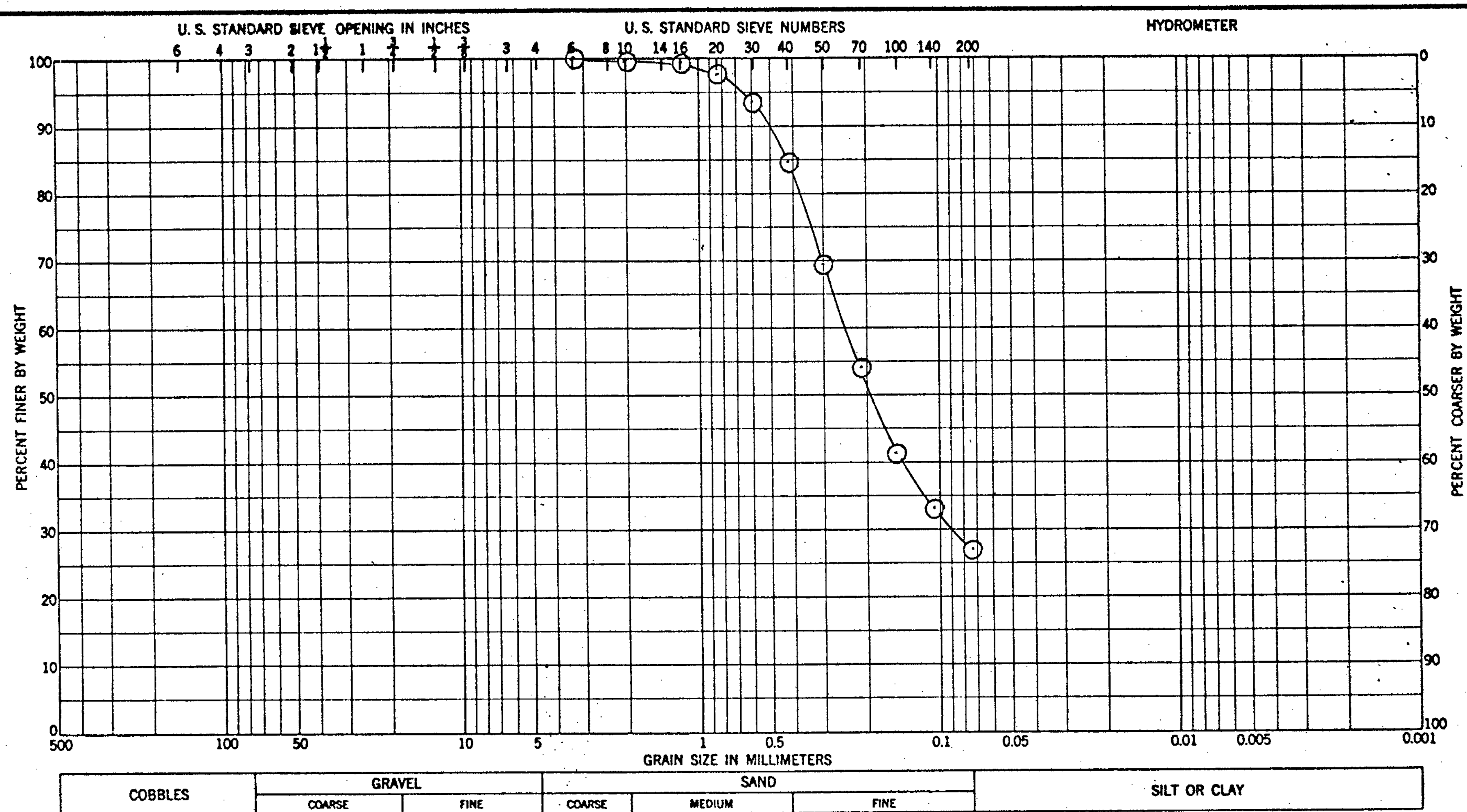
Boring No.: 485

Date: 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 32



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	2.5-3.0	SILTY SAND(SM) BROWN Gs= 2.70	10.1	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

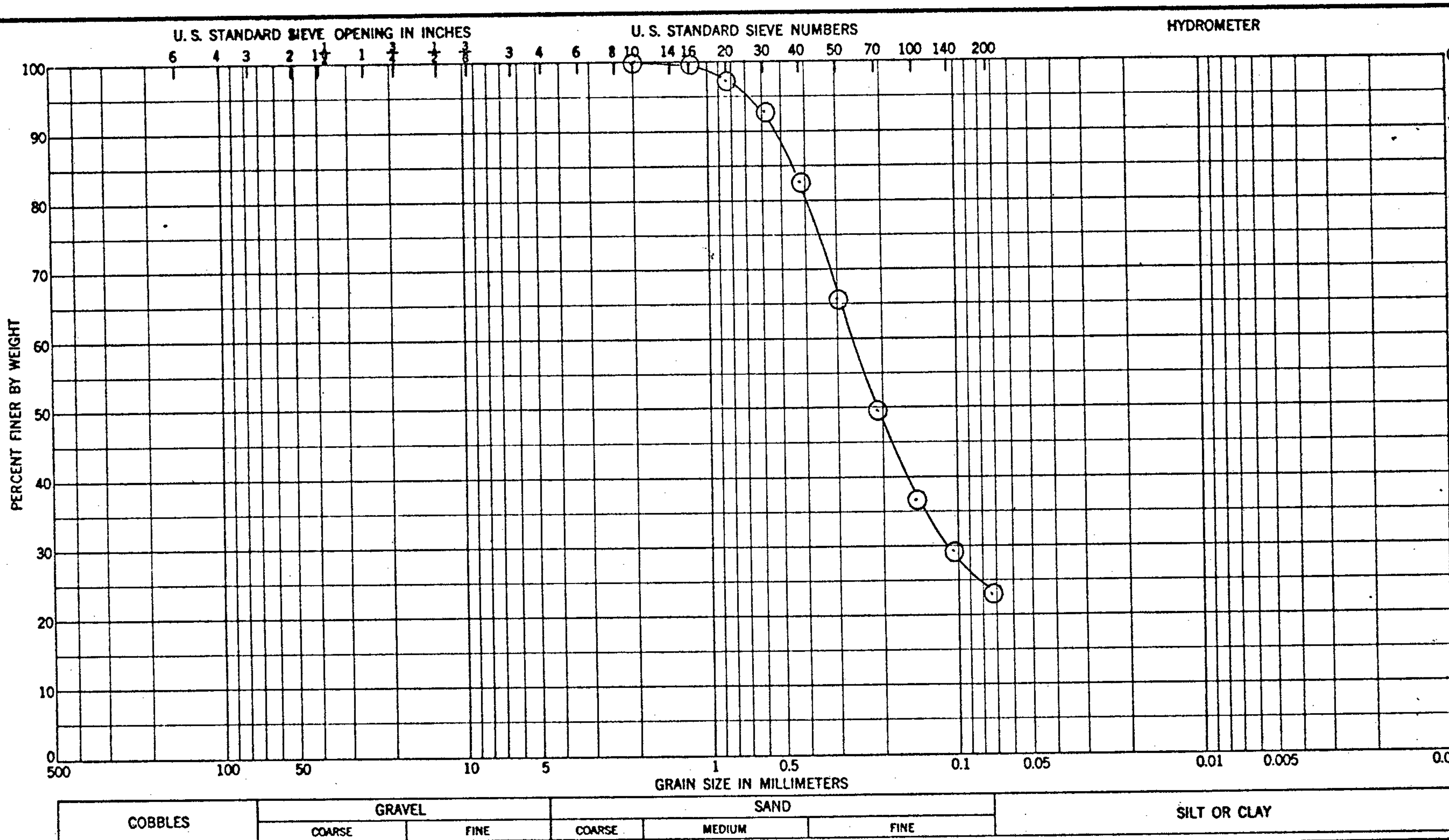
Boring No. 485

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 33



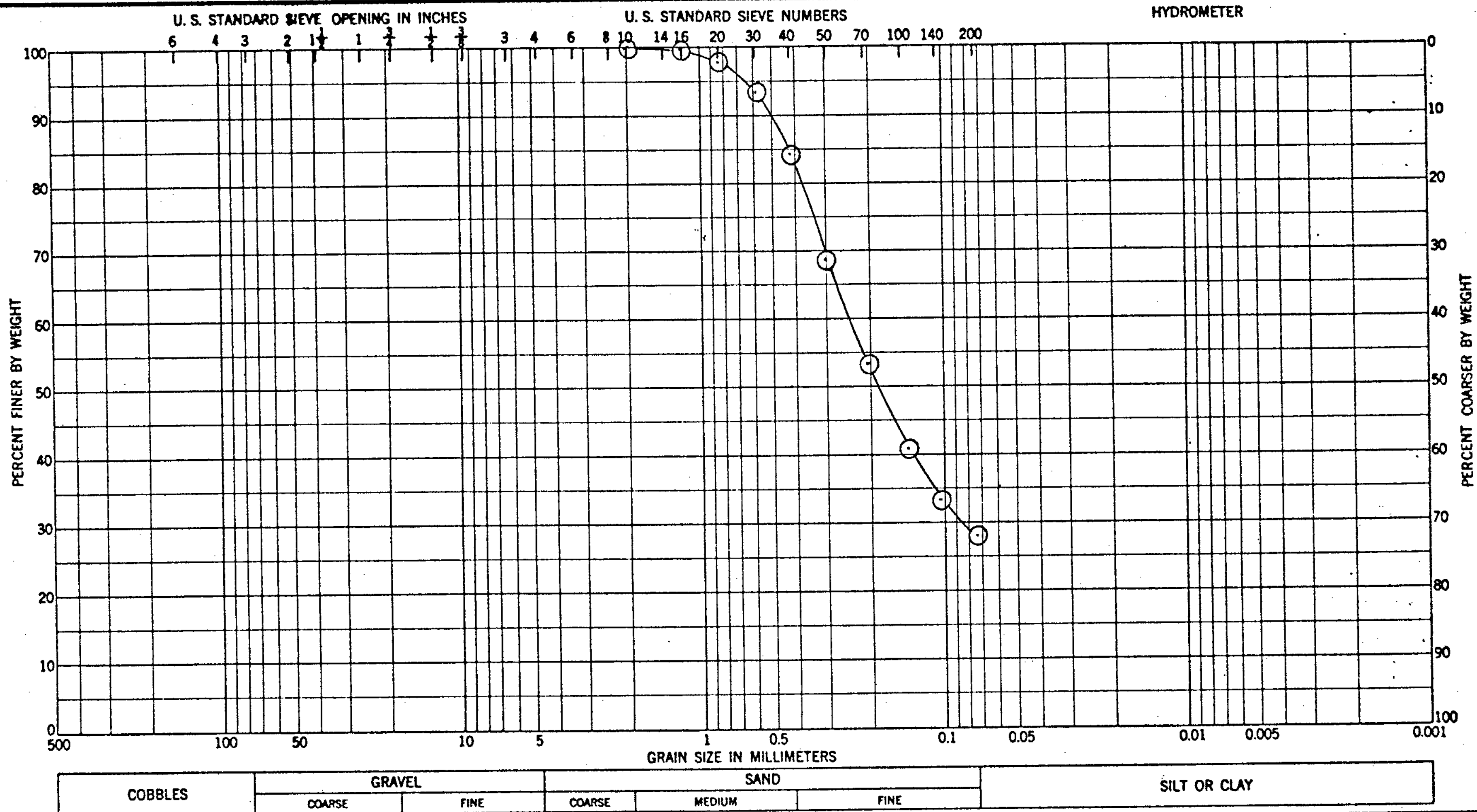
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	5.0-6.4	SILTY SAND(SM) BROWN	11.6	NP		
		Gs= 2.70				

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	485
Date	29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 34



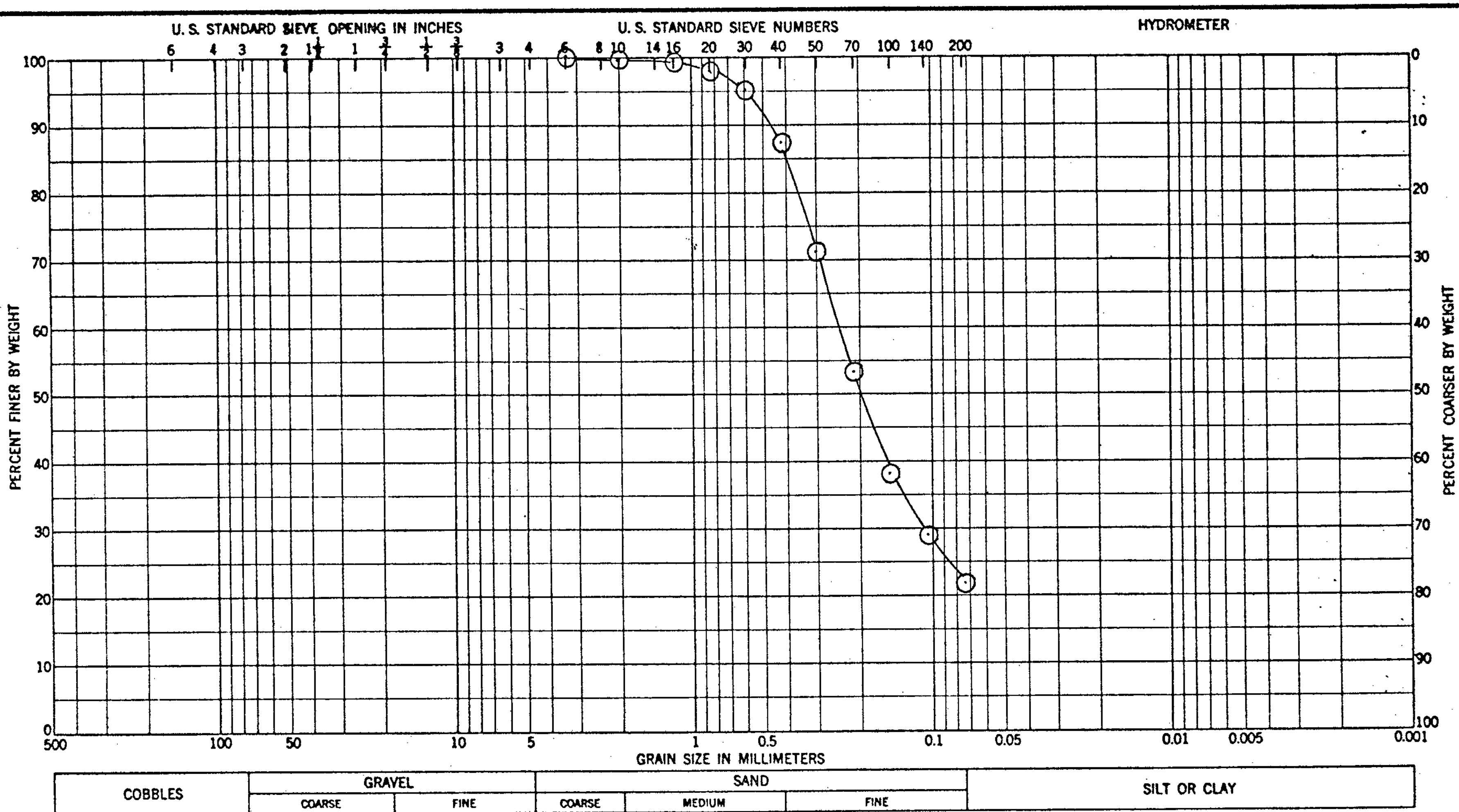
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	7.5-8.8	CLAYEY SAND(SC) BROWN Gs= 2.69	11.6	25	13	12

Project	ROCKY MOUNTAIN ARSENAL
Area	F. BASIN - DIKE
Boring No.	485
Date	29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 35



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	10.0-11.5	SILTY SAND(SM) BROWN Gs= 2.70	6.9	NP		

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

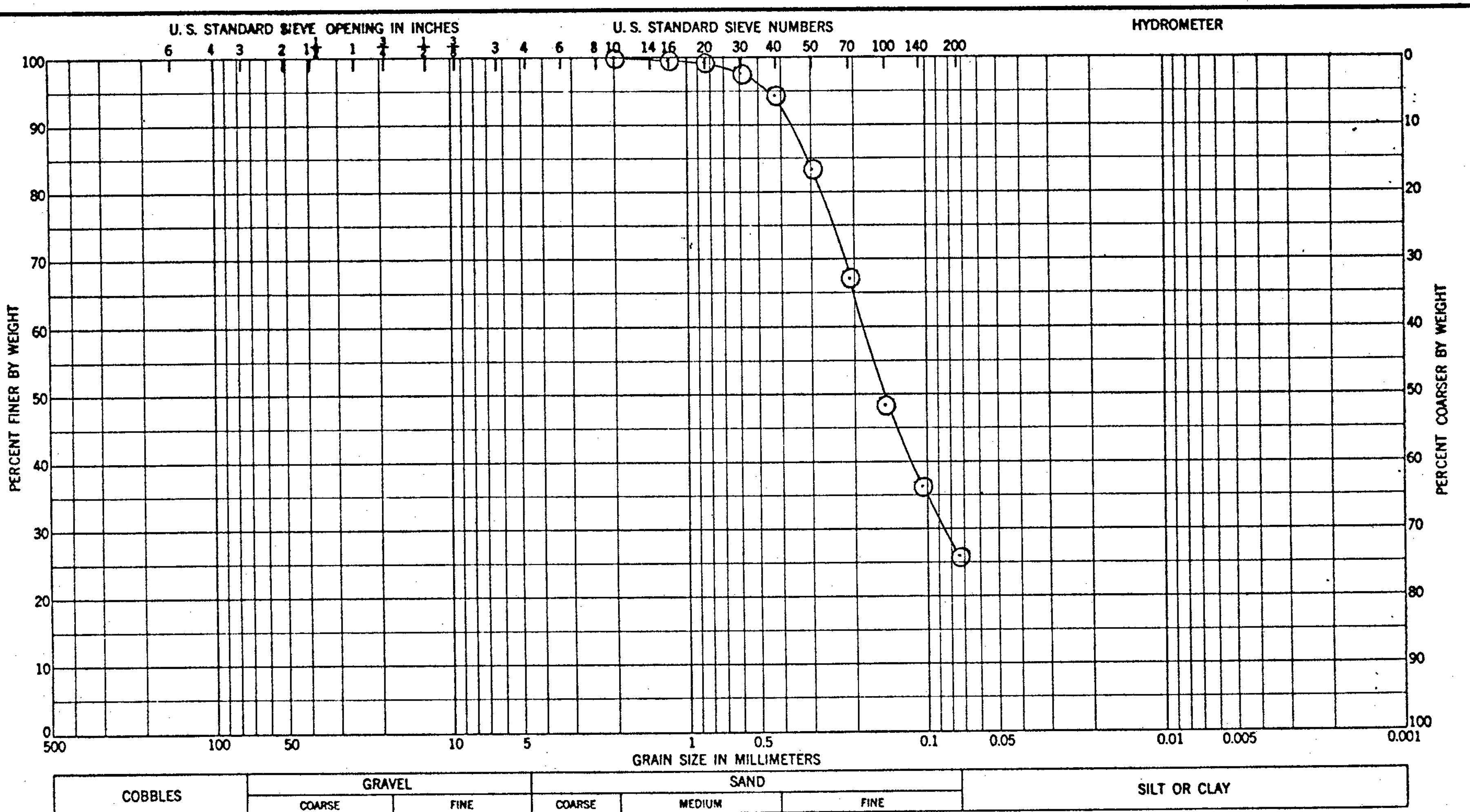
Boring No. 485

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 36



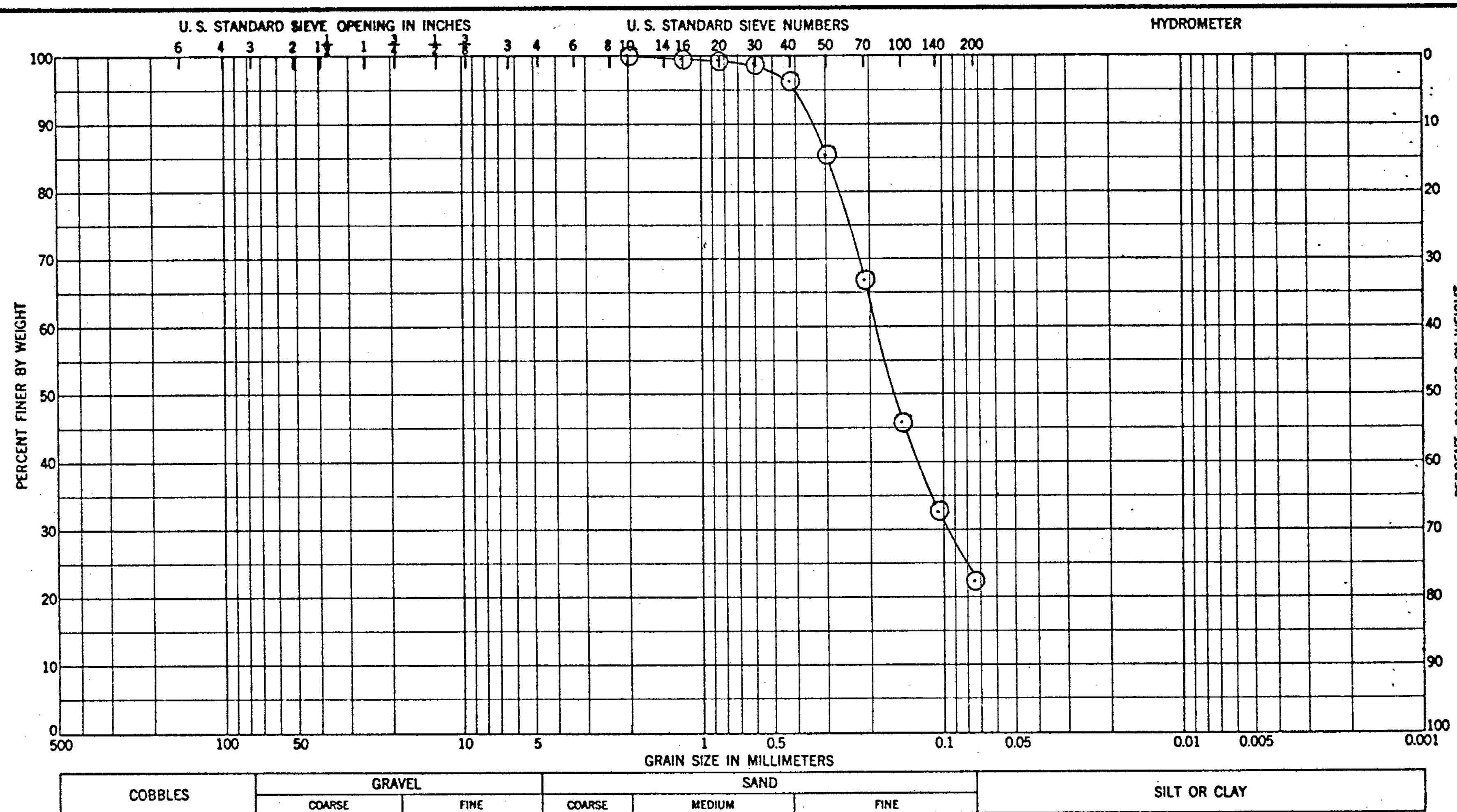
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	12.5-14.0	SILTY SAND(SM) BROWN	7.3	NP		
		Gs= 2.70				

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	485
Date	29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 37



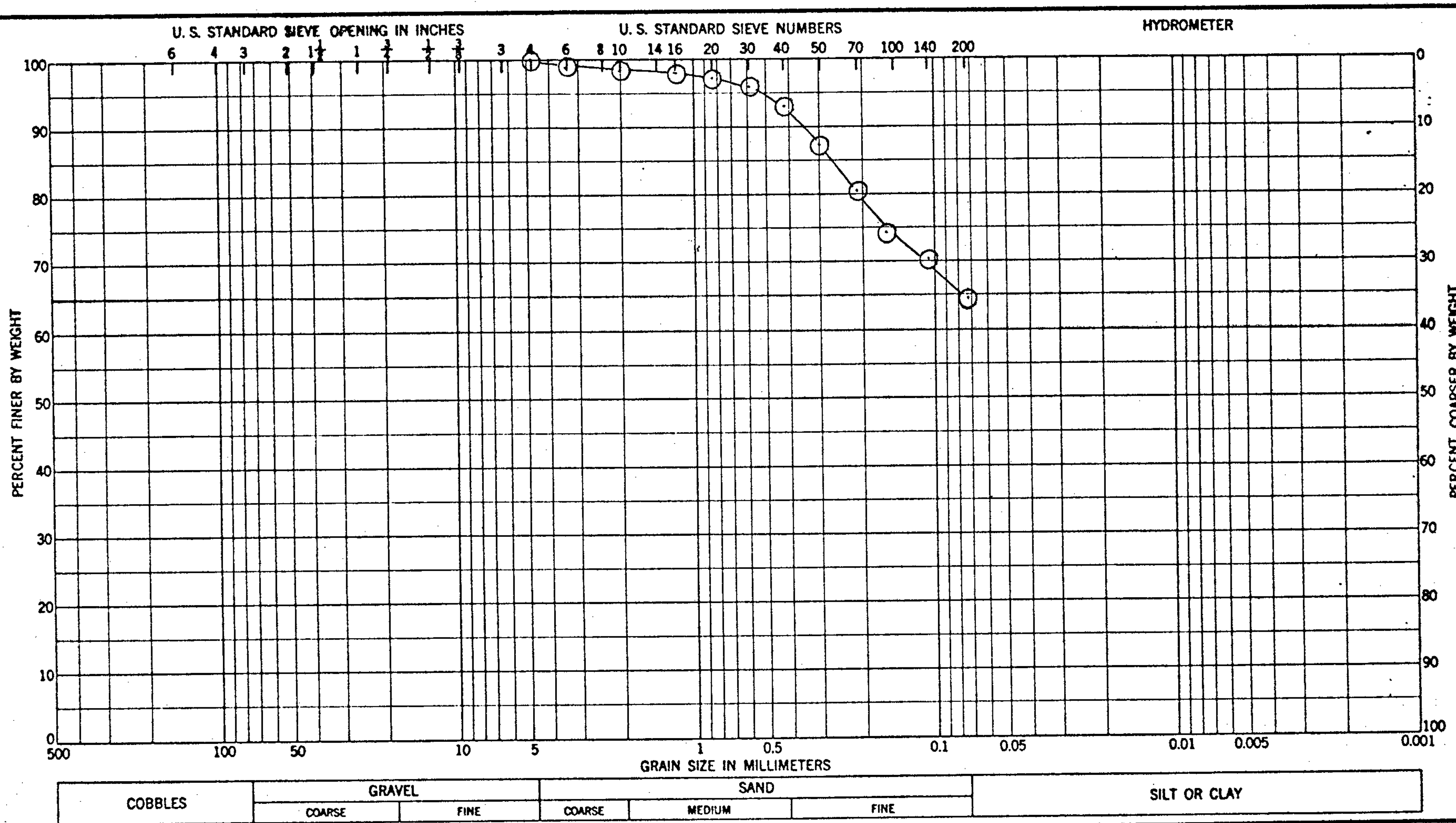
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
7	15.0-16.2	SILTY SAND(SM) BROWN	8.6	NP		
		Gs= 2.70				

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	485
Date	29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 38



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
8	17.5-18.7	SANDY CLAY(CL) BROWN Gs= 2.73	17.9	38	16	22

Project ROCKY MOUNTAIN ARSENAL

Area F BASIN - DIKE

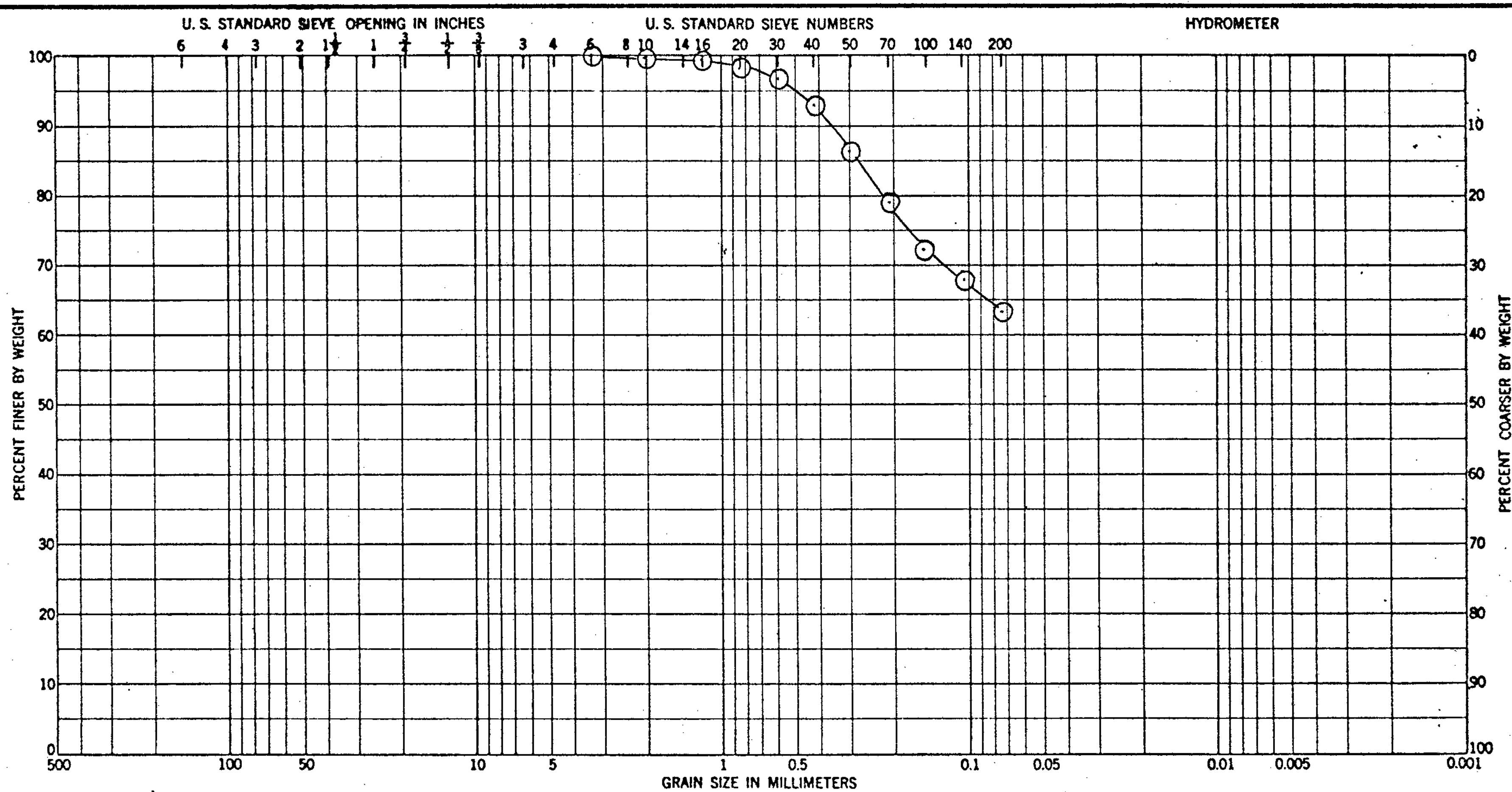
Boring No. 485

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 39



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
9	20.0-20.8	SANDY CLAY(CL) TAN Gs=2.74	26.7	45	18	27

Project ROCKY MOUNTAIN ARSENAL

Area F. BASIN - DIKE

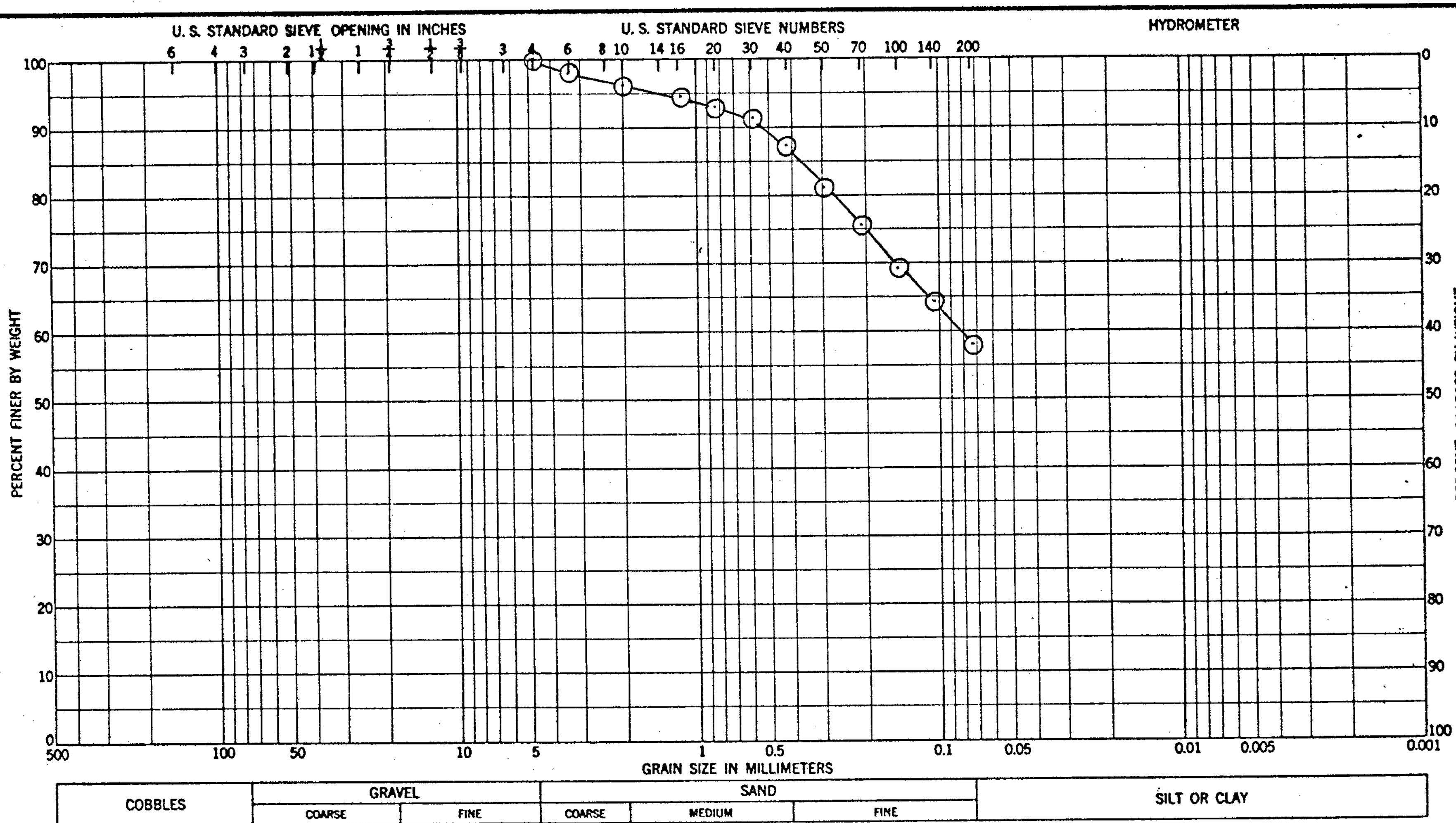
Boring No. 485

Date 29 DEC 77

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 40



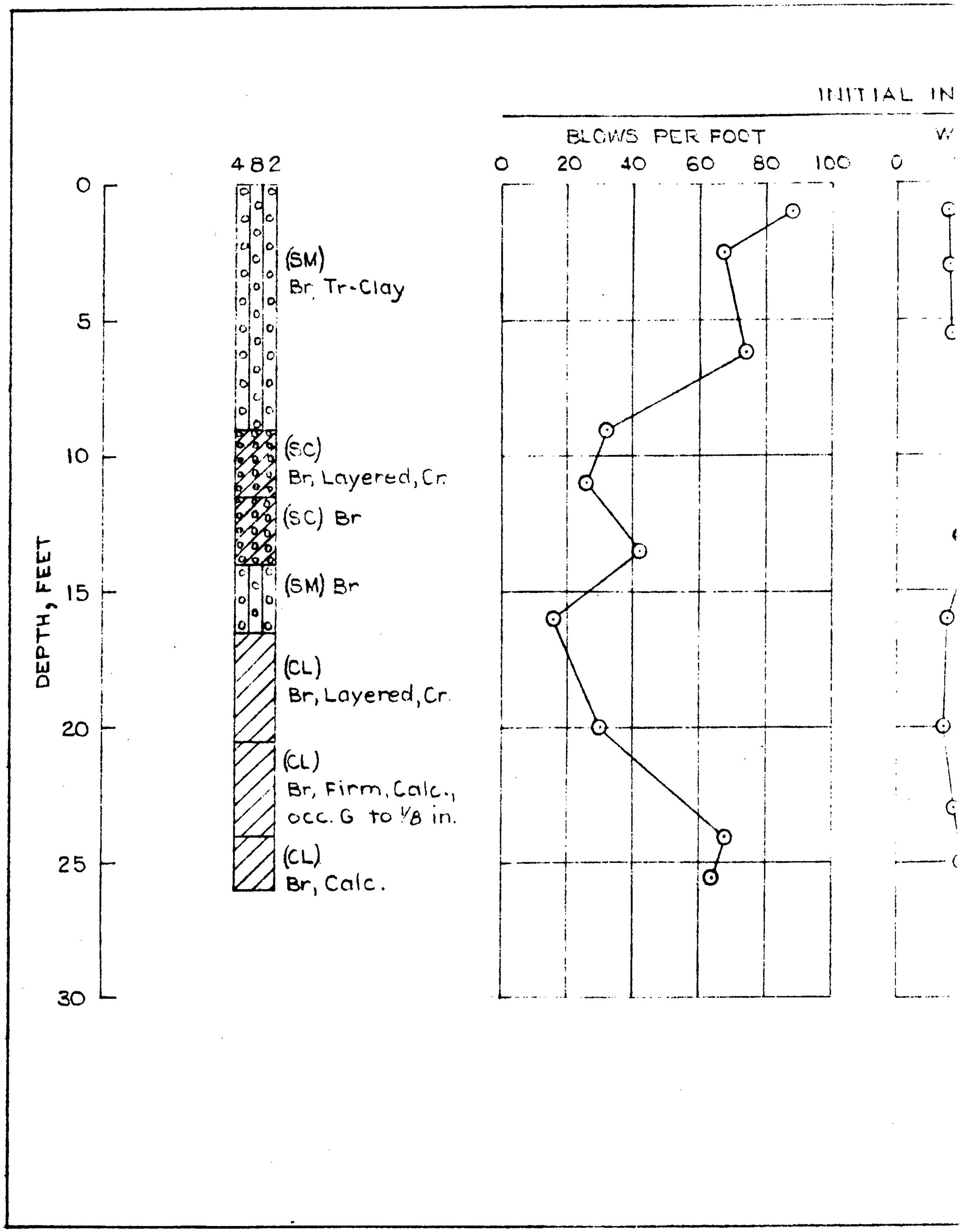
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
10	22.5-23.5	SANDY CLAY(CL) TAN	13.9	30	13	17
		Gs= 2.72				

Project	ROCKY MOUNTAIN ARSENAL
Area	F BASIN - DIKE
Boring No.	485
Date	29 DEC 77

GRADATION CURVES

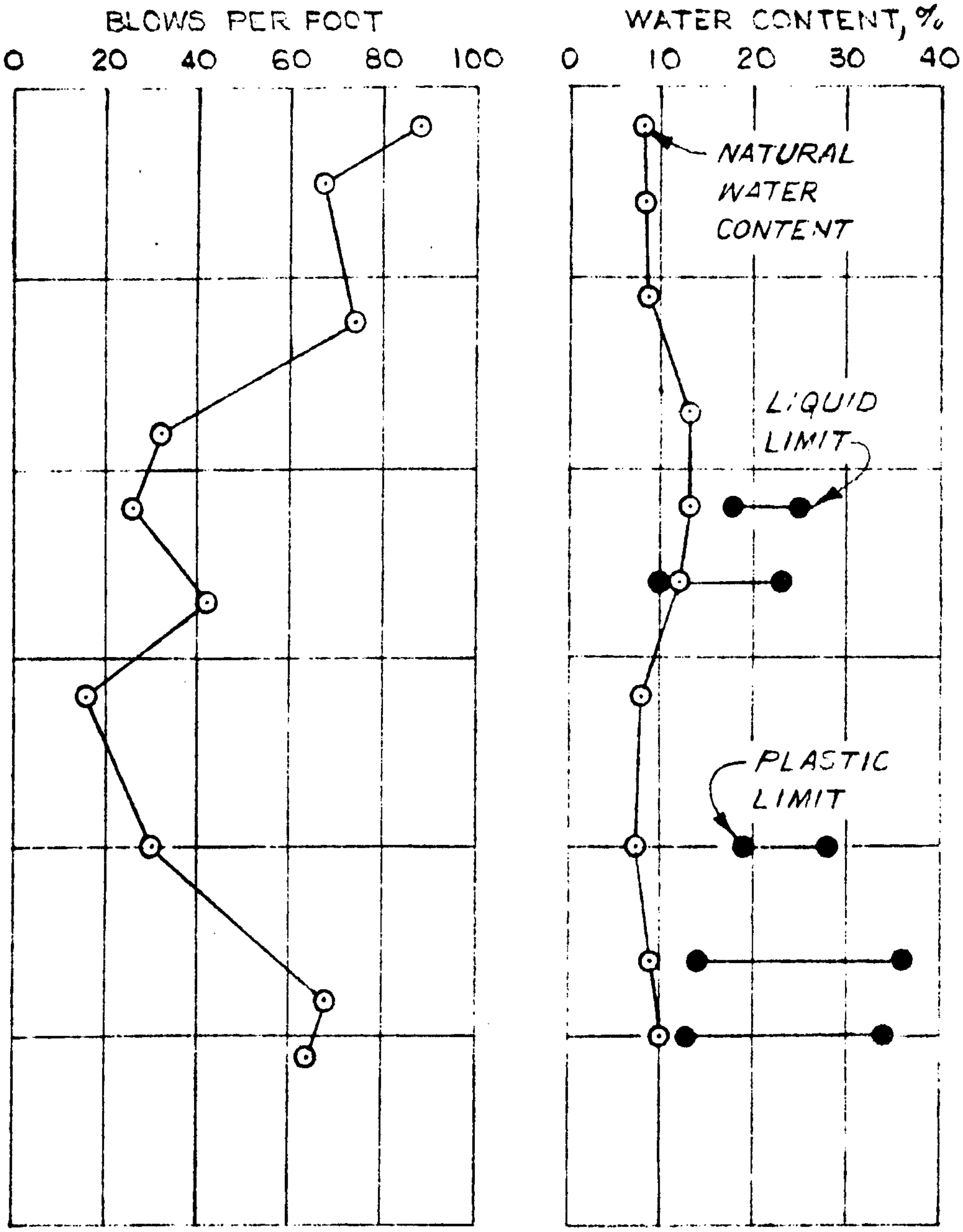
ENG FORM 1 MAY 63 2087

Figure 41


INITIAL IN
BLOWS PER FOOT
0 20 40 60 80 100
0
W
482
DEPTH, FEET
0
5
10
15
20
25
30
(SM) Br. Tr-Clay
(SC) Br, Layered, Cr.
(SC) Br
(SM) Br
(CL) Br, Layered, Cr.
(CL) Br, Firm, Calc., occ. G to 1/8 in.
(CL) Br, Calc.

1

INITIAL INVESTIGATION



ESTIMATED VALUES		
$\gamma_{(t)}$, PCF	ϕ, DEG	C, PSF
131	47	0
127	36	0
134	32	0
137	0	4350
138	0	9930

ESTIMATED VALUES

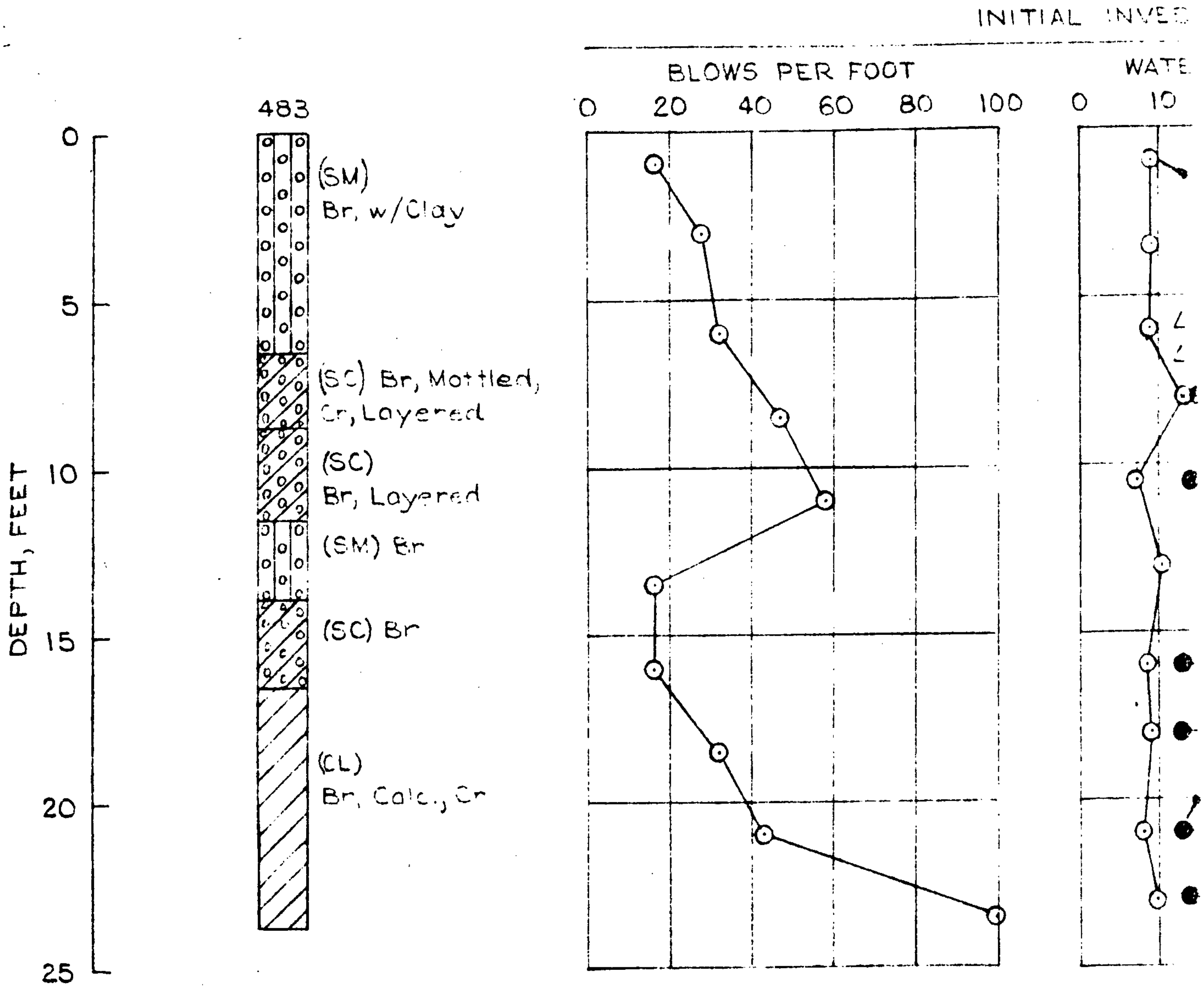
$\gamma_{(t)}$, PCF	ϕ, DEG	C, PSF
131	47	0
127	36	0
134	32	0
137	0	4350
138	0	9930

FINAL INVESTIGATION

SELECTED LABORATORY VALUES					
	Q TEST		S TEST		
$\gamma_{(t)}$, PCF	ϕ	C	ϕ	C	DEPTH, FEET
SOIL #1					0–16
132	32	900	34	0	
SOIL #2					16–25
115	15	840	32	0	

GRAPHIC BORING LOGS & STRENGTH VALUES
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

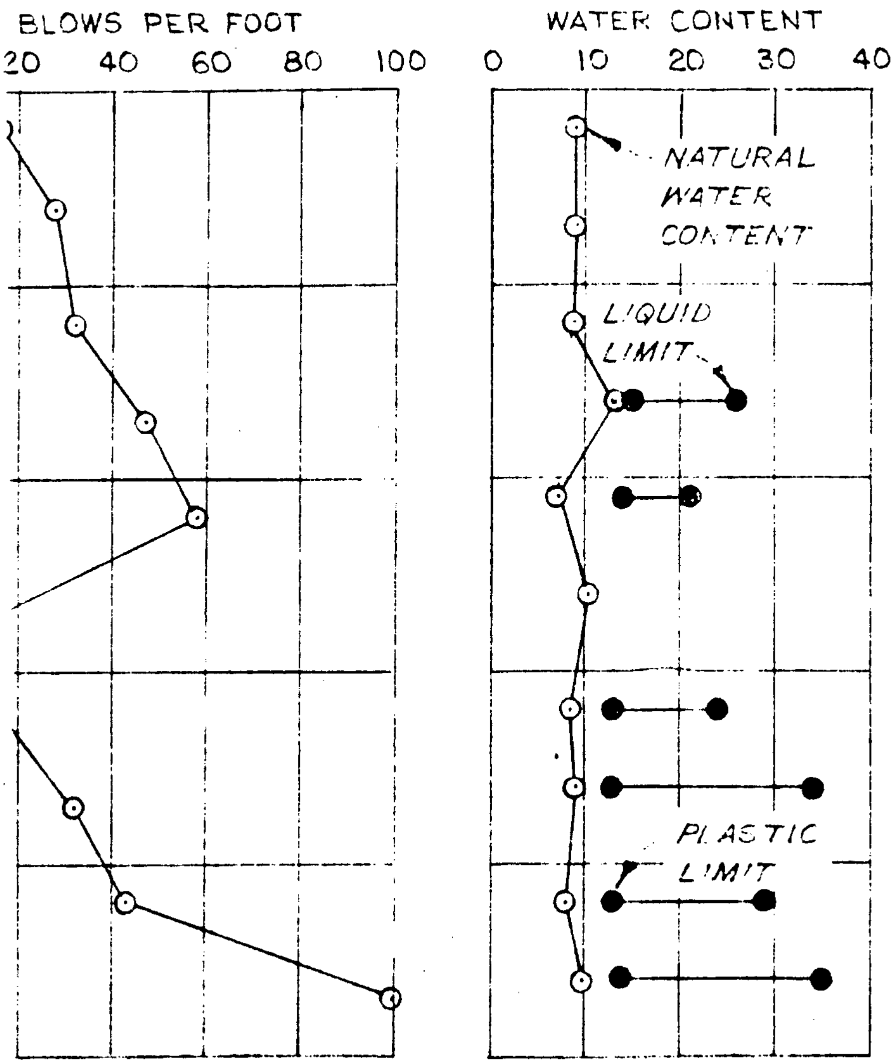
3



INITIAL INVES
BLOWS PER FOOT
0 20 40 60 80 100
WATE
0 10
483
DEPTH, FEET
0
5
10
15
20
25
(SM)
Br, w/Clay
(SC) Br, Mottled,
Cr, Layered
(SC)
Br, Layered
(SM) Br
(SC) Br
(CL)
Br, Calc., Cr

1

INITIAL INVESTIGATION



ESTIMATED VALUES

γ_w, PCF	ϕ, DEG.	C, PSF
135	34	0
132	41	0
134	32	0
137	0	5550
0	0	15000

40

ESTIMATED VALUES

γ_w, PCF	ϕ, DEG.	C, PSF
135	34	0
132	41	0
134	32	0
137	0	5550
0	0	15000

FINAL INVESTIGATION

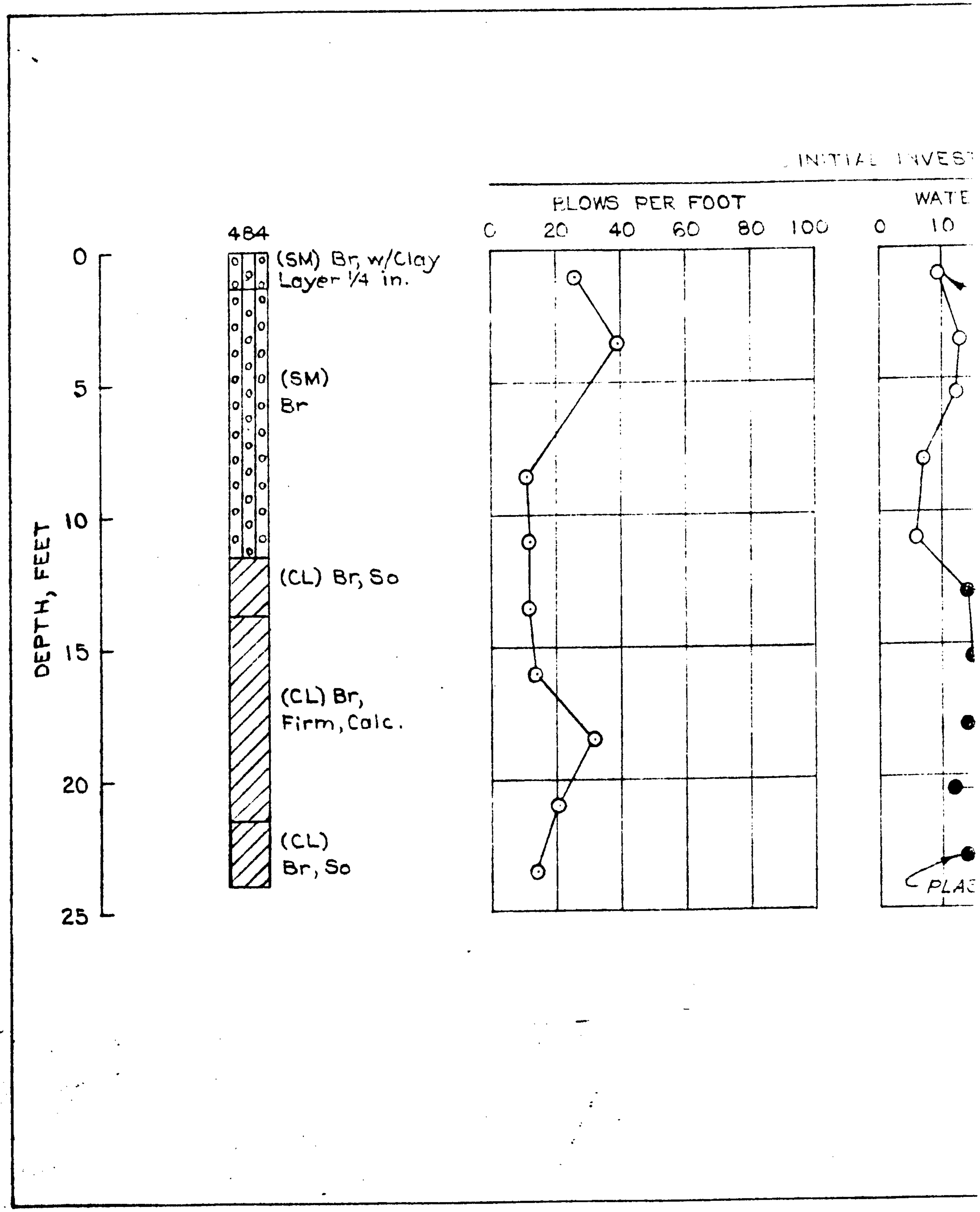
SELECTED LABORATORY VALUES				
	Q TEST		S TEST	
γ_w, PCF	ϕ	C	ϕ	C
SOIL #1				
132	30	900	34	0
SOIL #2				
115	15	840	32	0

DEPTH, FEET: 0, 5, 10, 15, 20, 25

GRAPHIC BORING LOGS & STRENGTH VALUES
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

Figure 43

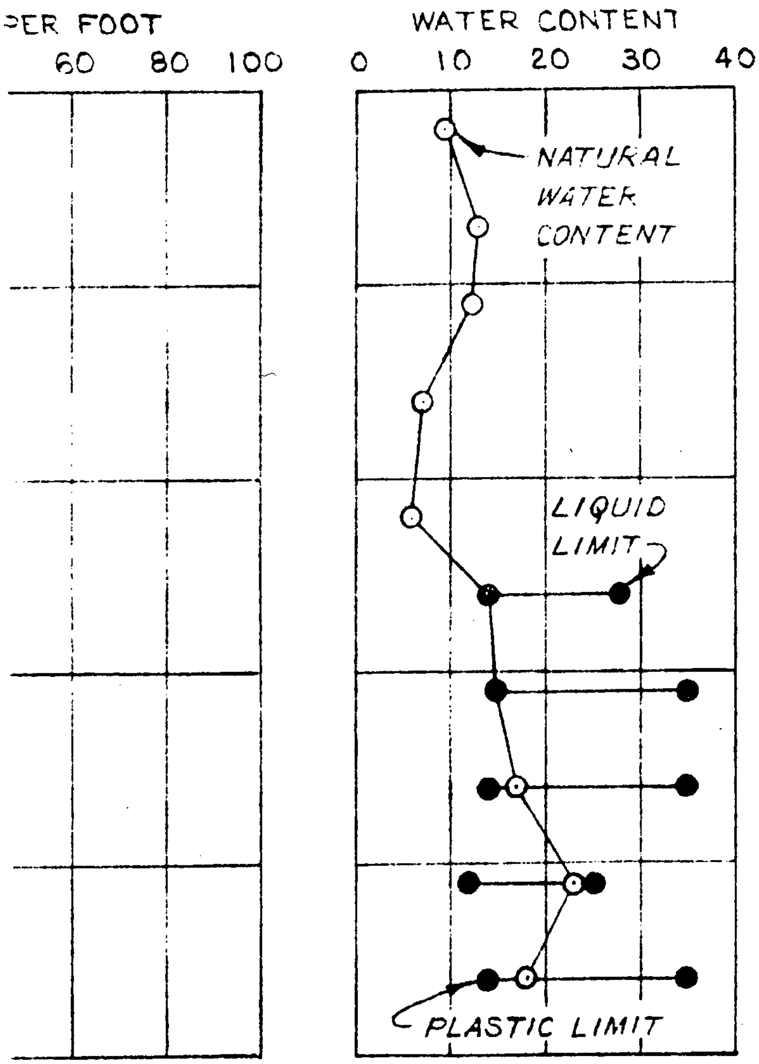
3



INITIAL INVEST
BLOWS PER FOOT
0 20 40 60 80 100
WATE
0 10
484
DEPTH, FEET
0
5
10
15
20
25
(SM) Br, w/Clay Layer 1/4 in.
(SM) Br
(CL) Br, So
(CL) Br, Firm, Calc.
(CL) Br, So
PLA

1

INITIAL INVESTIGATION



ESTIMATED VALUES

γ_{ur}, PCF	ϕ, DEG.	C, PSF
129	36	0
133	31	0
119	0	2760

F

SELECTED
γ_w, PCF
132
115

2

ESTIMATED VALUES		
γ_w, PCF	ϕ, DEG.	C, PSF
129	36	0
133	31	0
119	0	2760

FINAL INVESTIGATION

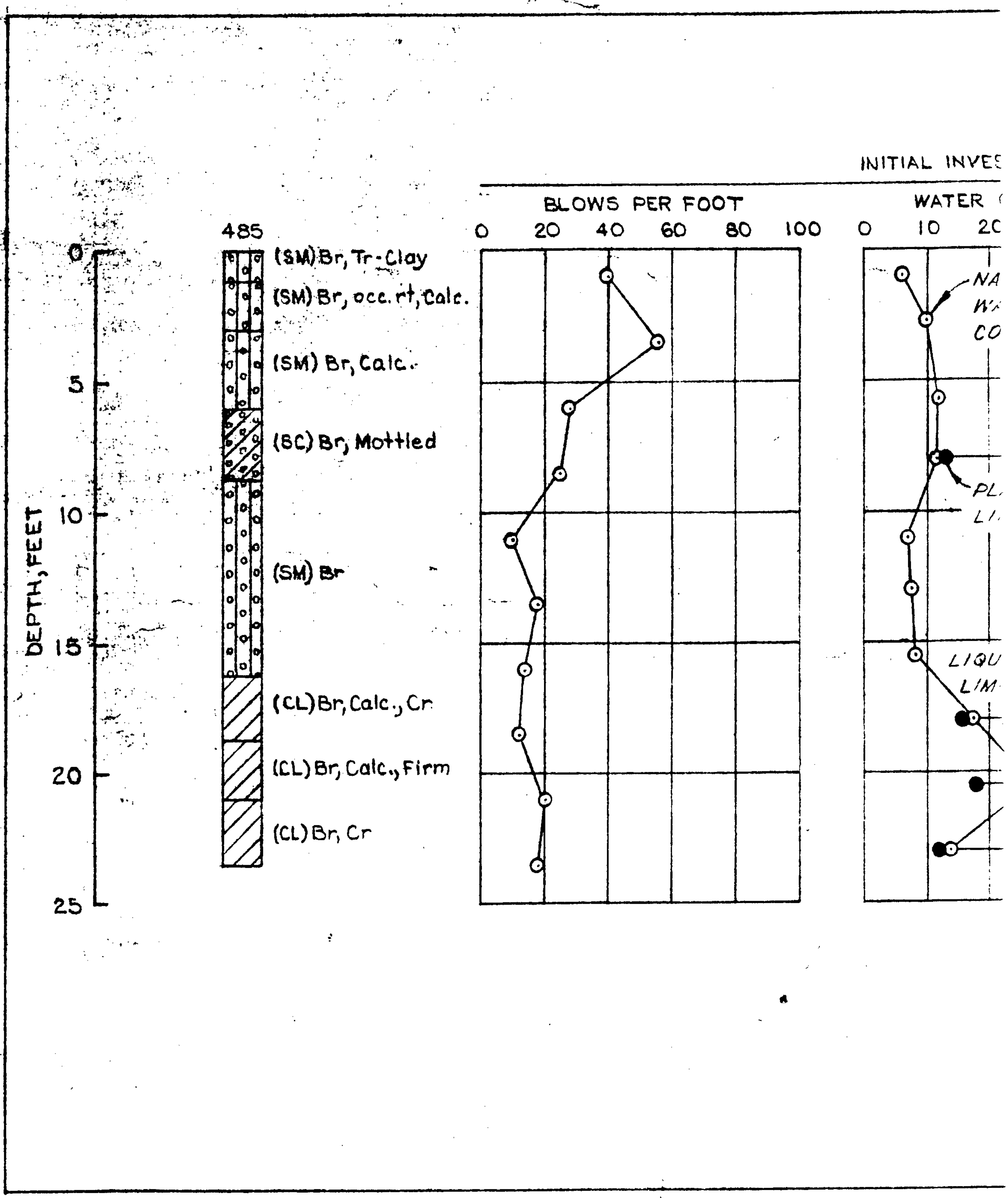
SELECTED LABORATORY VALUES					
	Q TEST		S TEST		
γ_w, PCF	ϕ	c	ϕ	c	
SOIL #1					
132	31.3	860	34	0	
SOIL #2					
115	15	840	32	0	

DEPTH, FEET: 0, 5, 10, 15, 20, 25

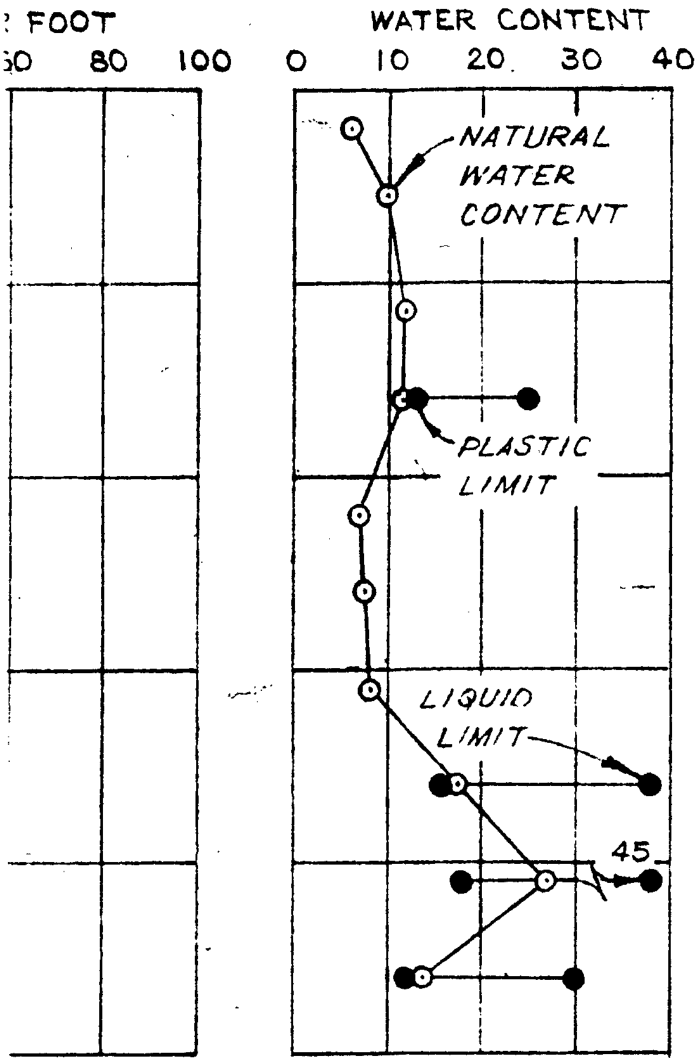
[illegible]HIC BORING LOGS & STRENGTH VALUES
DIKE STABILITY ANALYSIS
BASIN F,
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

Figure [illegible]

3


INITIAL INVES
BLOWS PER FOOT
0 20 40 60 80 100
WATER
0 10 20
485
DEPTH, FEET
0
5
10
15
20
25
(SM) Br, Tr-Clay
(SM) Br, occ. rt, Calc.
(SM) Br, Calc.
(SC) Br, Mottled
(SM) Br
(CL) Br, Calc., Cr
(CL) Br, Calc., Firm
(CL) Br, Cr
PL
LI
LIQU
LIM

INITIAL INVESTIGATION



ESTIMATED VALUES

γ_w, PCF	ϕ, DEG.	C, PSF
136	39	0
129	35	0
140	31	0
116	0	2650

FINA

SELECTED LA	
	Q T
γ_w, PCF	ϕ
132	31.3
115	15

GRAPHI

2

40

ESTIMATED VALUES		
γ_{ω}, PCF	ϕ, DEG.	C, PSF
136	39	0
129	35	0
140	31	0
116	0	2650

FINAL INVESTIGATION

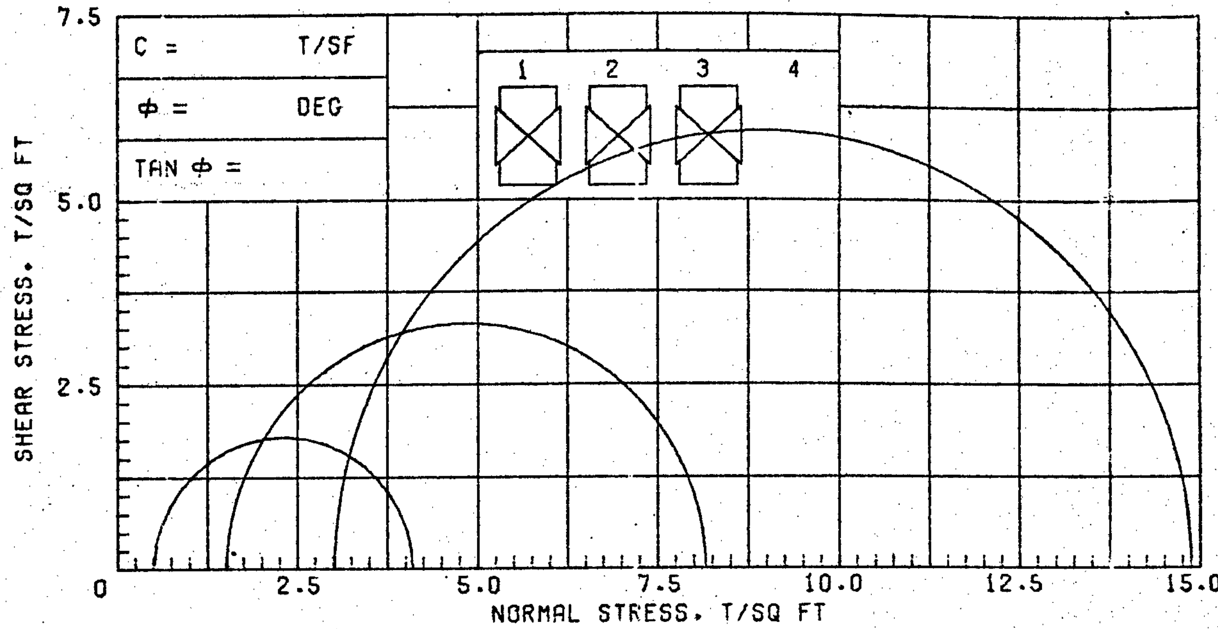
SELECTED LABORATORY VALUES					
		Q TEST		S TEST	
	γ_{ω}, PCF	ϕ	C	ϕ	C
SOIL #1	132	31.3	860	34	0
SOIL #2	115	15	840	32	0

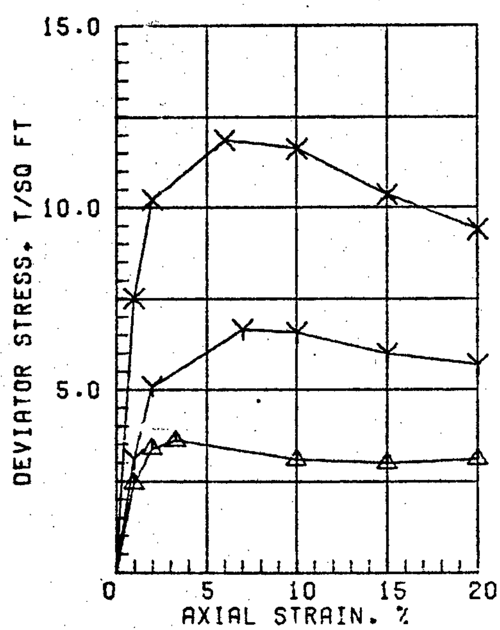
DEPTH, FEET: 0, 5, 10, 15, 20, 25

GRAPHIC BORING LOGS & STRENGTH VALUES
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

Figure [illegible]

3





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	7.8	8.1	7.9	
	DRY DENSITY, PCF	115.1	120.4	115.7	
	SATURATION, %	45.4	54.7	46.7	
	VOID RATIO	0.464	0.400	0.457	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		3.60	6.65	11.87	
TIME TO FAILURE, MIN.		19	23	18	
RATE OF STRAIN INCR.%		5		8	
INITIAL DIAMETER, IN.		1.40	1.40	1.40	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: SILTY SAND (SM), TAN;
CEMENTED SLIGHTLY

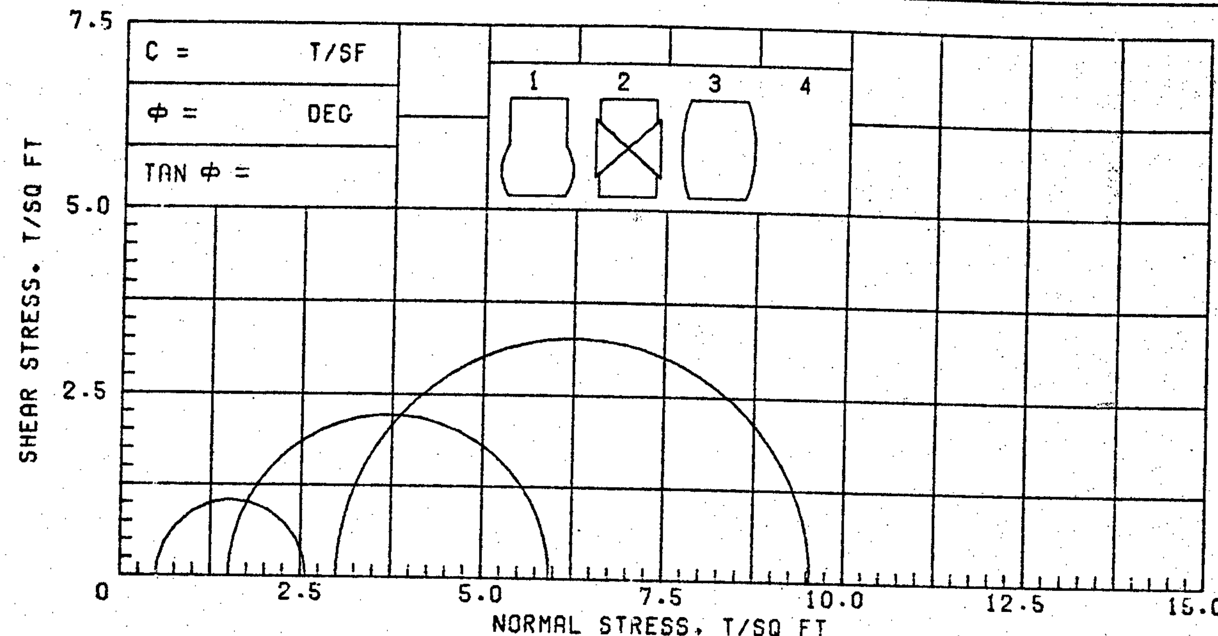
LL NP	PL NP	PI	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

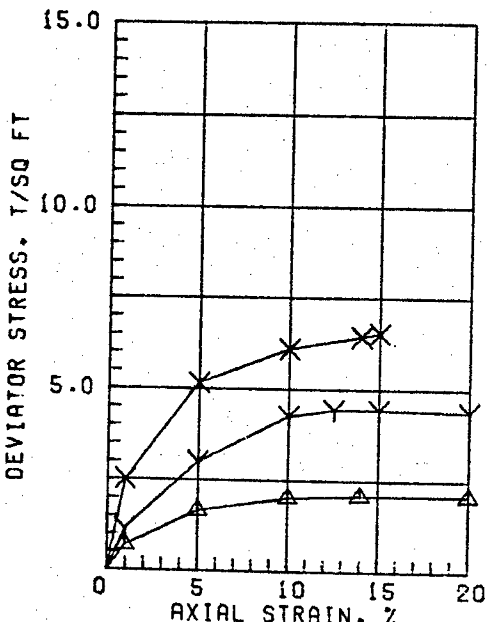
REMARKS:

PROJECT DIKE STABILITY	
ROCKY MOUNTAIN ARSENAL	
BORING NO. 482-U	SAMPLE NO. 1
DEPTH/ELEV 0.5-1.9	TECH. JAL
LABORATORY USAE WES	DATE 26 MAR 78

TRIAXIAL COMPRESSION TEST REPORT

Figure 46





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	11.7	12.1	12.7	
	DRY DENSITY, PCF	111.0	114.2	112.1	
	SATURATION, %	60.9	68.7	68.1	
	VOID RATIO	0.518	0.476	0.504	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	2.08	4.44	6.54	
	TIME TO FAILURE, MIN.	29	28	26	
	RATE OF STRAIN INCR.%				
	INITIAL DIAMETER, IN.	1.39	1.40	1.41	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: SILTY SAND (SM), TAN

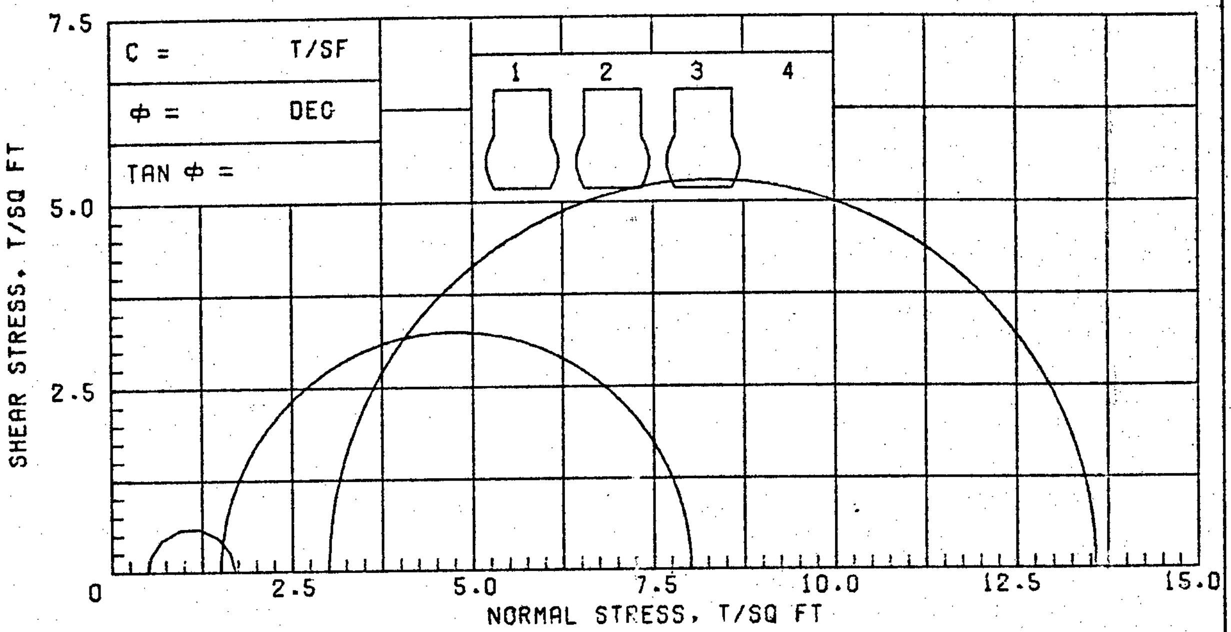
LL	PL	PI	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

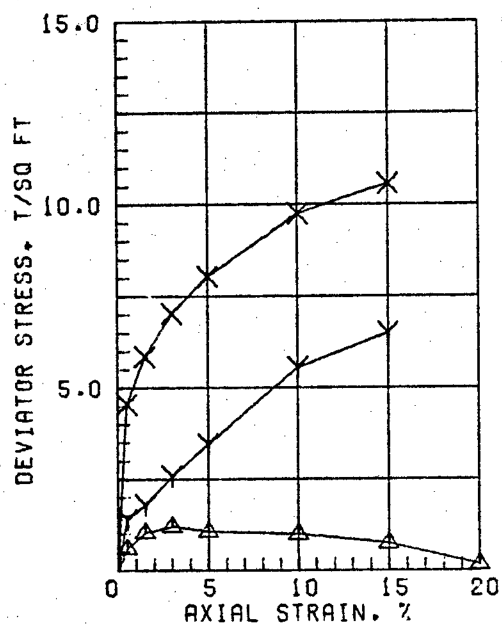
REMARKS:

PROJECT DIKE STABILITY	
ROCKY MOUNTAIN ARSENAL	
BORING NO. 482-U	SAMPLE NO. 2
DEPTH/ELEV 5.5-6.55	TECH. JAL
LABORATORY USAE WES	DATE 27 MAR 78

TRIAXIAL COMPRESSION TEST REPORT

Figure 47





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	13.1	12.4	12.2	
	DRY DENSITY, PCF	117.2	116.0	119.9	
	SATURATION, %	80.6	73.9	81.2	
	VOID RATIO	0.439	0.453	0.406	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	1.20	6.50	10.57	
	TIME TO FAILURE, MIN.	13	189	14	
	RATE OF STRAIN INCR.%	5			
	INITIAL DIAMETER, IN.	1.40	1.40	1.39	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

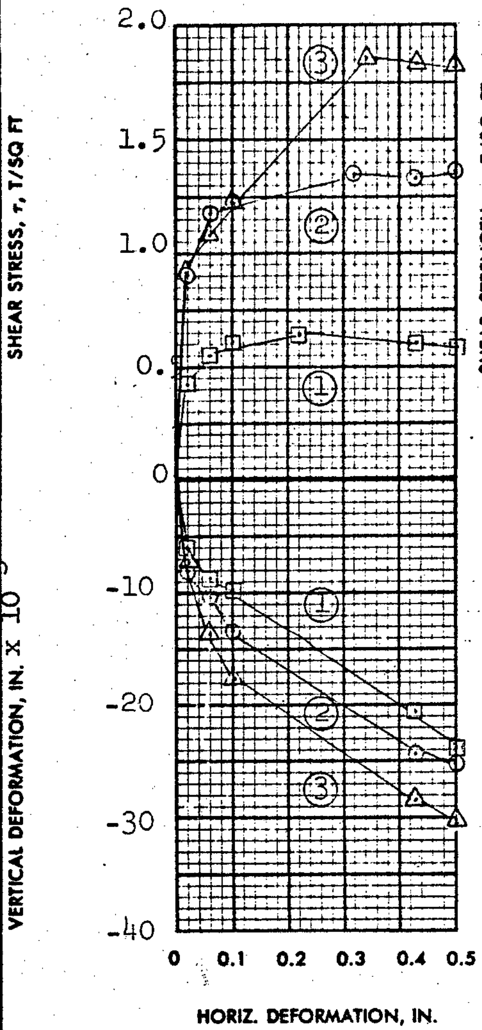
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC)

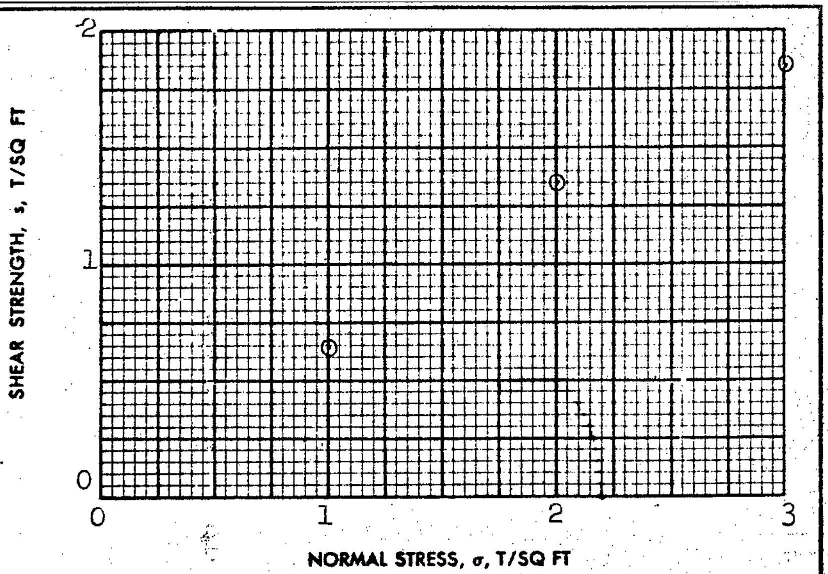
DARK BROWN; FRIABLE

LL 28	PL 13	PI 15	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 482-U	SAMPLE NO. 3
	DEPTH/ELEV 10.0-11.1	TECH. CR
	LABORATORY USAE WES	DATE 27 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 48





SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

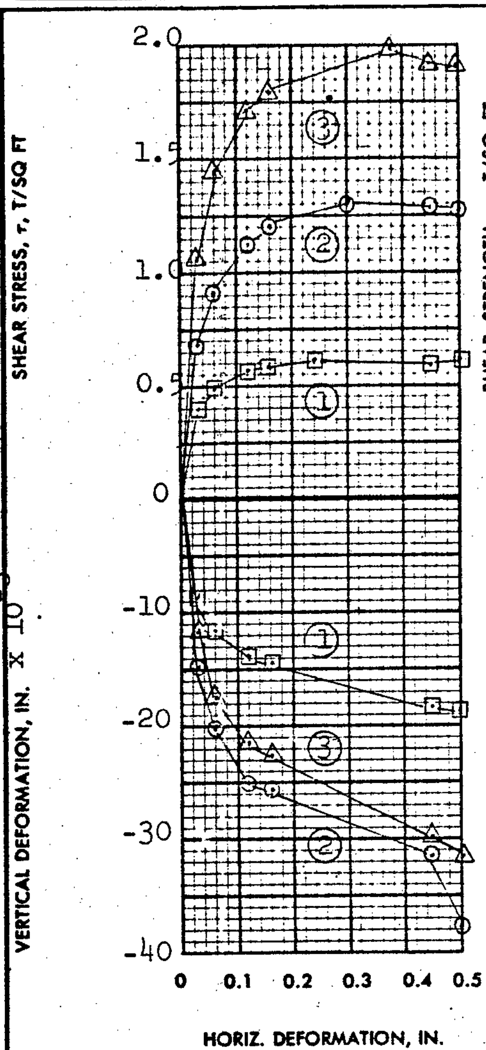
☒ CONTROLLED STRAIN

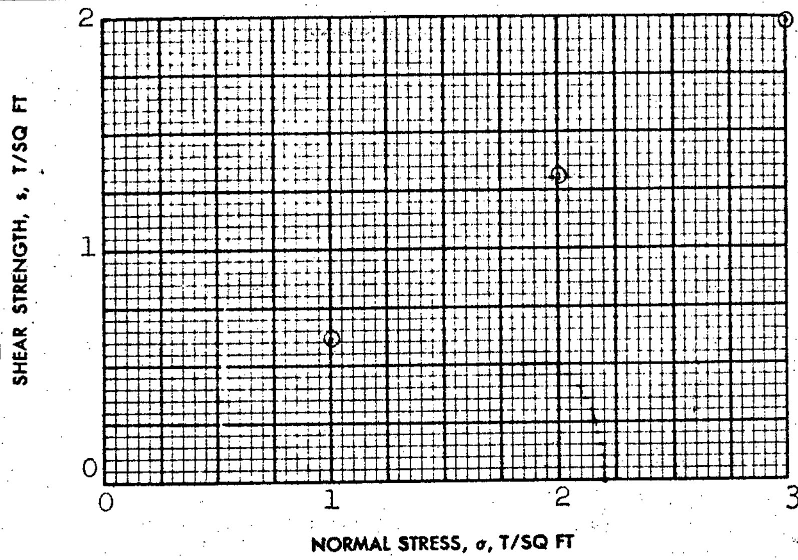
				1	2	3	
TEST NO.				1	2	3	
INITIAL	WATER CONTENT		w_o	4.4%	4.4 %	4.6 %	%
	VOID RATIO		e_o	0.761	0.750	0.769	
	SATURATION		S_o	15.6 %	15.8 %	16.1 %	%
	DRY DENSITY, LB/CU FT		γ_d	95.7	96.3	95.3	
VOID RATIO AFTER CONSOLIDATION			e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN			t_{50}				
FINAL	WATER CONTENT		w_f	12.5%	12.8%	13.4%	%
	VOID RATIO		e_f				
	SATURATION		S_f	%	%	%	%
NORMAL STRESS, T/SQ FT			σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT			τ_{max}	0.64	1.35	1.85	
ACTUAL TIME TO FAILURE, MIN			t_f	660	930	990	
RATE OF STRAIN, IN./MIN				.00037	.00037	.00037	
ULTIMATE SHEAR STRESS, T/SQ FT			τ_{ult}				

TYPE OF SPECIMEN UNDISTURBED	3.00 IN. SQUARE	0.547 IN. THICK	
CLASSIFICATION SILTY SAND (SM), TAN			
LL NP	PL NP	PI NP	G_s 2.70

REMARKS ____________

PROJECT	DIKE STABILITY
	ROCKY MOUNTAIN ARSENAL
AREA	
BORING NO. 482-U	SAMPLE NO. 4
DEPTH EL 15.0-16.0	DATE 30 MAR 78
RCH	**DIRECT SHEAR TEST REPORT**





SHEAR STRENGTH PARAMETERS

ϕ' = ______

TAN ϕ' = ______

c' = ______ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	7.0%	6.8 %	7.1 %	%
	VOID RATIO	e_o	0.664	0.654	0.662	
	SATURATION	S_o	28.5 %	28.1 %	29.0 %	%
	DRY DENSITY, LB/CU FT	γ_d	101.3	101.9	101.4	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	5	2	2	
FINAL	WATER CONTENT	w_f	14.9%	15.8 %	16.3 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.61	1.30	1.99	
ACTUAL TIME TO FAILURE, MIN		t_f	750	960	1170	
RATE OF STRAIN, IN./MIN			.00033	.00033	.00033	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

TYPE OF SPECIMEN UNDISTURBED — 3.00 IN. SQUARE — 0.547 IN. THICK

CLASSIFICATION CLAYEY SILTY SAND(SC-SM)

LL 23 | PL 17 | PI 6 | G_s 2.70

REMARKS

PROJECT DIKE STABILITY
ROCKY MOUNTAIN ARSENAL

AREA

BORING NO. 482-U — SAMPLE NO. 5

DEPTH EL 16.1-17.2 — DATE 31 MAR 78

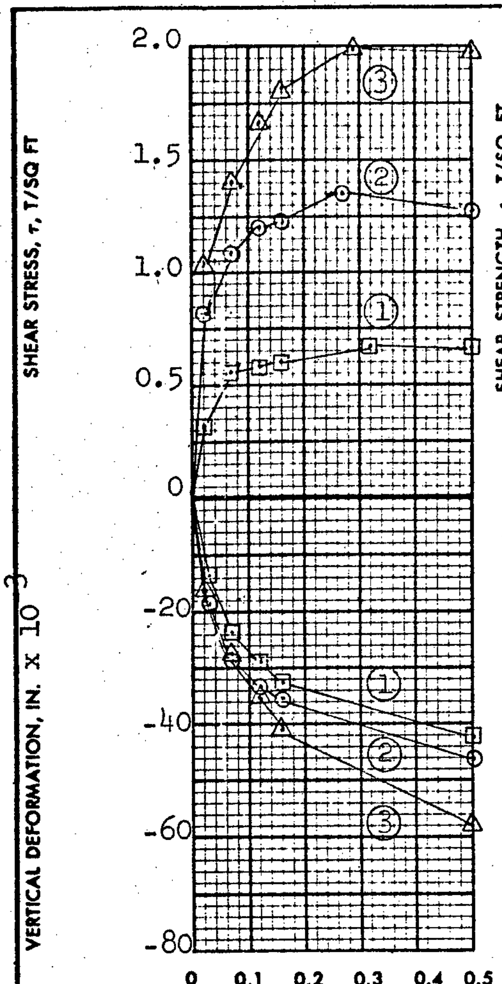
RCH

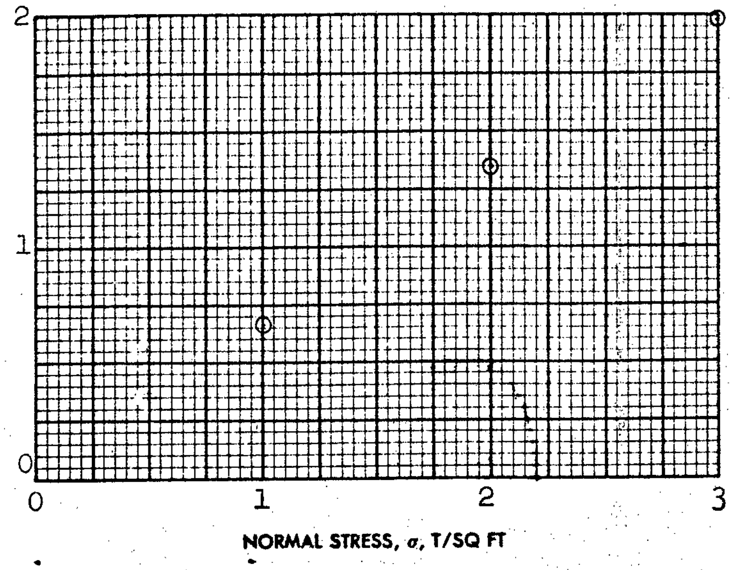
DIRECT SHEAR TEST REPORT

ENG FORM 1 JUN 65 **2092** (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1966 OF—214-945

Figure 50





				1	2	3	
TEST NO.				1	2	3	
INITIAL	WATER CONTENT		w_o	14.1%	15.2%	15.4%	%
	VOID RATIO		e_o	0.991	0.993	0.995	
	SATURATION		S_o	38.7%	41.6%	42.1%	%
	DRY DENSITY, LB/CU FT		γ_d	85.3	85.2	85.1	
VOID RATIO AFTER CONSOLIDATION			e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN			t_{50}	3	<1	<1	
FINAL	WATER CONTENT		w_f	26.0%	24.9%	23.1%	%
	VOID RATIO		e_f				
	SATURATION		S_f	%	%	%	%
NORMAL STRESS, T/SQ FT			σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT			τ_{max}	0.67	1.35	1.99	
ACTUAL TIME TO FAILURE, MIN			t_f	900	690	810	
RATE OF STRAIN, IN./MIN				.00038	.00038	.00038	
ULTIMATE SHEAR STRESS, T/SQ FT			τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED	3.00 IN. SQUARE	0.547 IN. THICK	
CLASSIFICATION SANDY CLAY (CL), LIGHT BROWN			
LL 39	PL 15	PI 24	G_s 2.72

REMARKS ____________

PROJECT DIKE STABILITY
ROCKY MOUNTAIN ARSENAL

AREA

BORING NO. 482-U — SAMPLE NO. 6

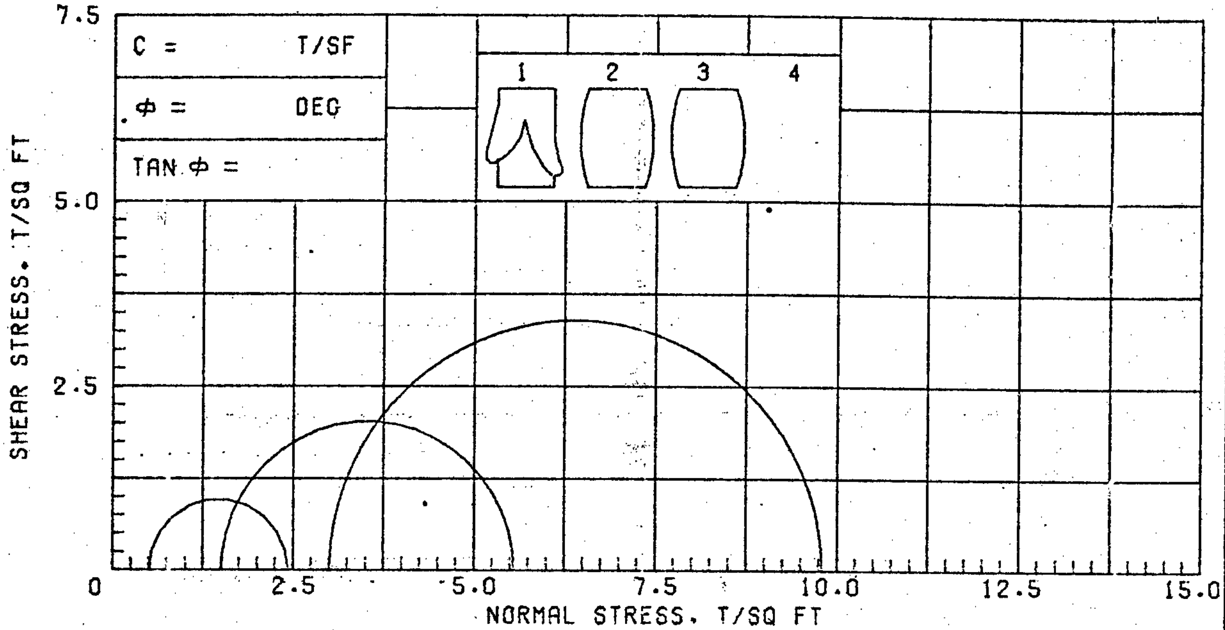
DEPTH EL 20.0-21.1 — DATE 01 APR 78

RCH

DIRECT SHEAR TEST REPORT

ENG FORM 2092 1 JUN 65 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1966 OF—214-945



SPECIMEN NO.		△1	Y2	X3	4
INITIAL	WATER CONTENT, %	10.6	10.3	9.9	
	DRY DENSITY, PCF	108.9	108.1	105.6	
	SATURATION, %	52.2	49.7	44.8	
	VOID RATIO	0.548	0.560	0.596	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		1.94	4.05	6.79	
TIME TO FAILURE, MIN.		24	30	32	
RATE OF STRAIN INCR.%					
INITIAL DIAMETER, IN.		1.40	1.40	1.40	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

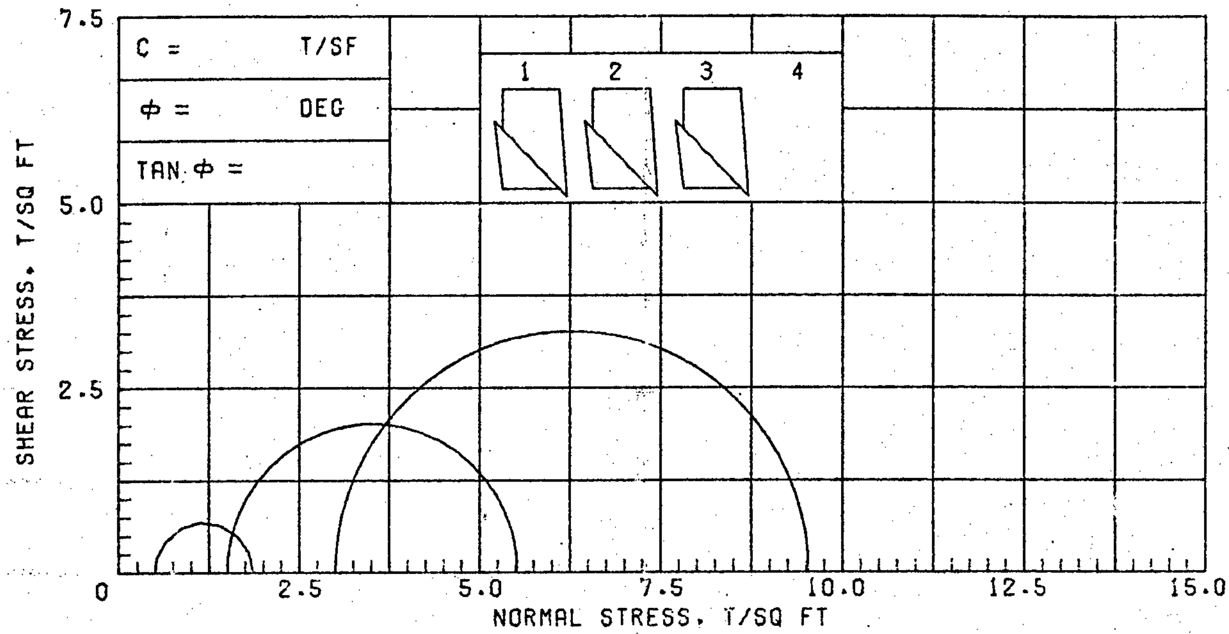
CONTROLLED-STRAIN TEST

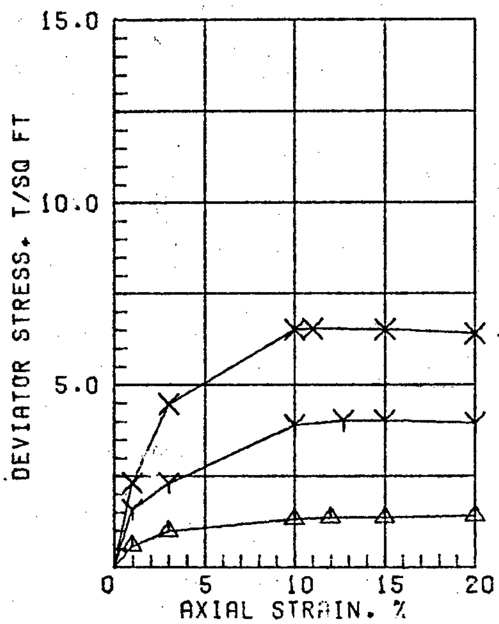
DESCRIPTION OF SPECIMENS: CLAYEY SILTY SAND (SC-SM), BROWN

LL 22	PL 16	PI 6	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 483-U	SAMPLE NO. 1
	DEPTH/ELEV 0.0-1.7	TECH. RE
	LABORATORY USAE WES	DATE 27 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 52





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	10.6	11.0	11.0	
	DRY DENSITY, PCF	108.4	111.7	109.3	
	SATURATION, %	51.5	58.4	54.8	
	VOID RATIO	0.555	0.509	0.542	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	1.36	4.03	6.53	
	TIME TO FAILURE, MIN.	20	25	19	
	RATE OF STRAIN INCR.%				
	INITIAL DIAMETER, IN.	1.39	1.39	1.39	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

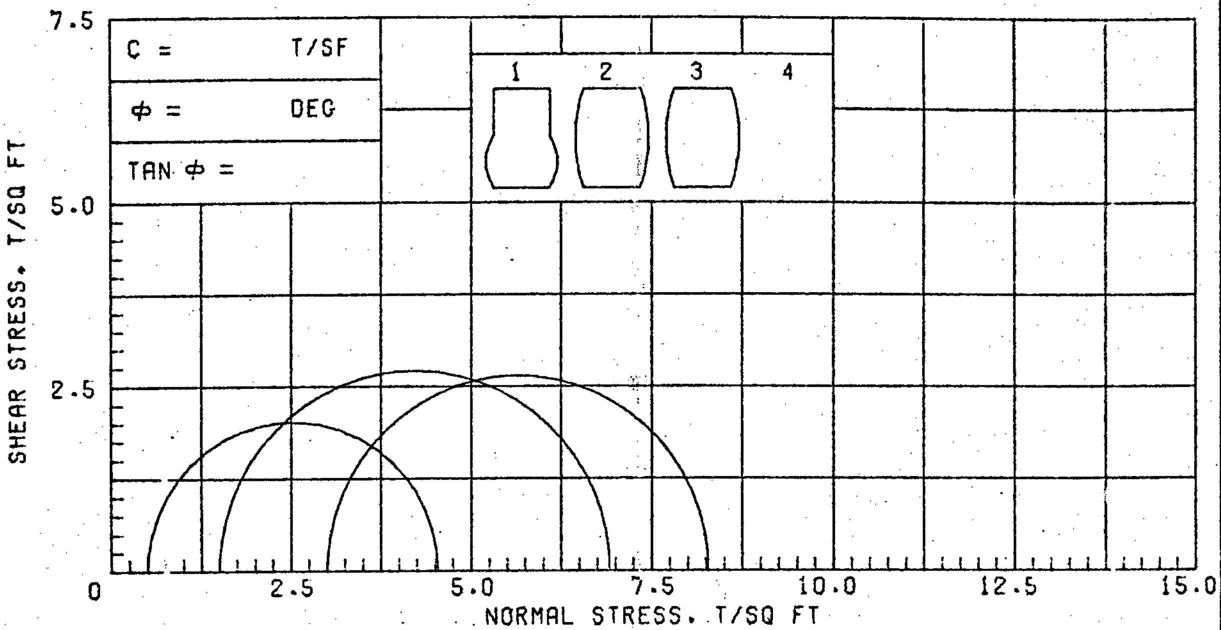
CONTROLLED-STRAIN TEST

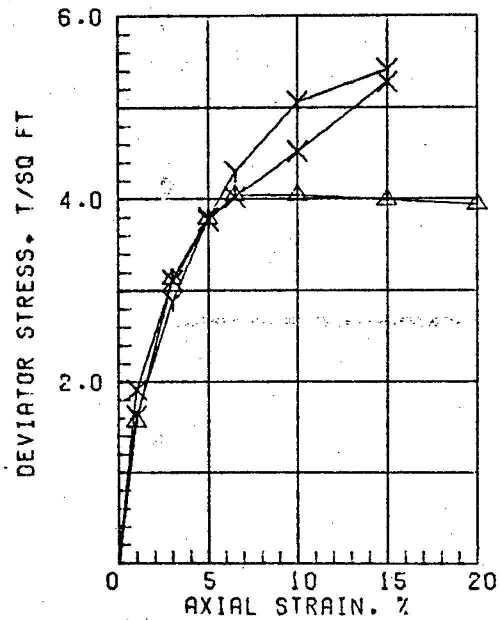
DESCRIPTION OF SPECIMENS; CLAYEY SANDY (SC); TAN

LL 26	PL 13	PI 13	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

REMARKS;	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 483-U	SAMPLE NO. 2
	DEPTH/ELEV 5.0-6.2	TECH. JAL
	LABORATORY USAE WES	DATE 28 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 53





		Δ1	Y2	X3	4
SPECIMEN NO.		Δ1	Y2	X3	4
INITIAL	WATER CONTENT, %	12.3	12.7	12.1	
	DRY DENSITY, PCF	118.8	119.5	119.1	
	SATURATION, %	79.2	83.5	78.6	
	VOID RATIO	0.419	0.411	0.416	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		4.04	5.42	5.28	
TIME TO FAILURE, MIN.		11	19	18	
RATE OF STRAIN INCR.%					
INITIAL DIAMETER, IN.		1.39	1.39	1.40	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

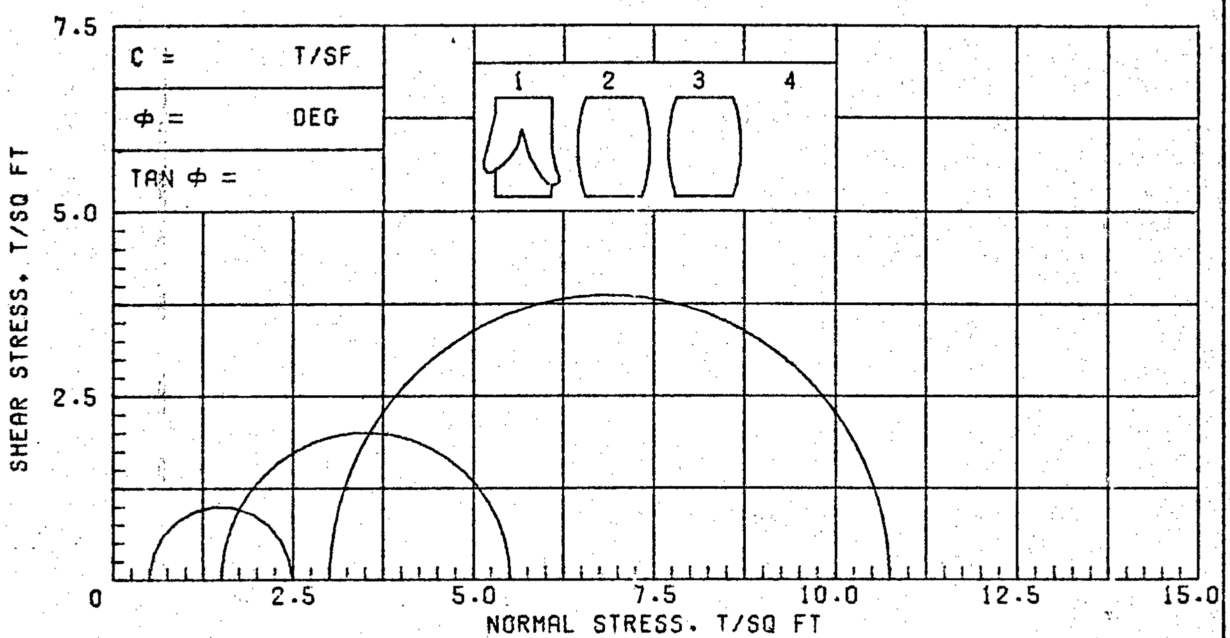
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC).

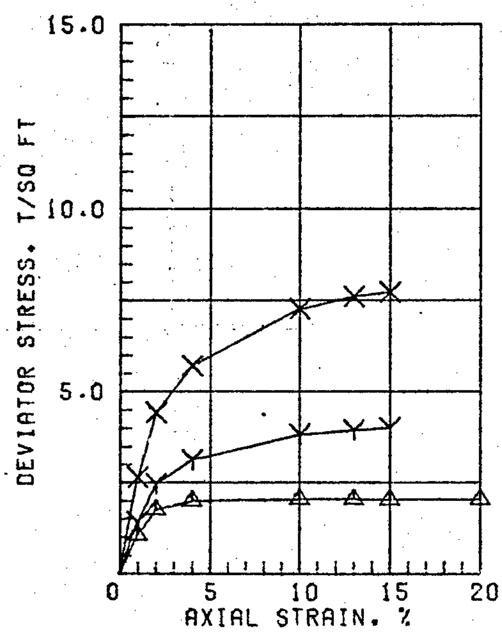
TAN: FRIABLE

LL 26	PL 15	PI 11	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 483-U	SAMPLE NO. 4
	DEPTH/ELEV 11.0-12.3	TECH. CR
	LABORATORY USAE WES	DATE 28 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 54





SPECIMEN NO.		△1	Y2	X3	4
INITIAL	WATER CONTENT, %	8.5	8.8	8.8	
	DRY DENSITY, PCF	104.8	103.7	106.1	
	SATURATION, %	38.0	38.2	40.6	
	VOID RATIO	0.602	0.620	0.583	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		2.00	4.01	7.74	
TIME TO FAILURE, MIN.		23	29	24	
RATE OF STRAIN INCR.%		5			
INITIAL DIAMETER, IN.		1.41	1.40	1.40	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

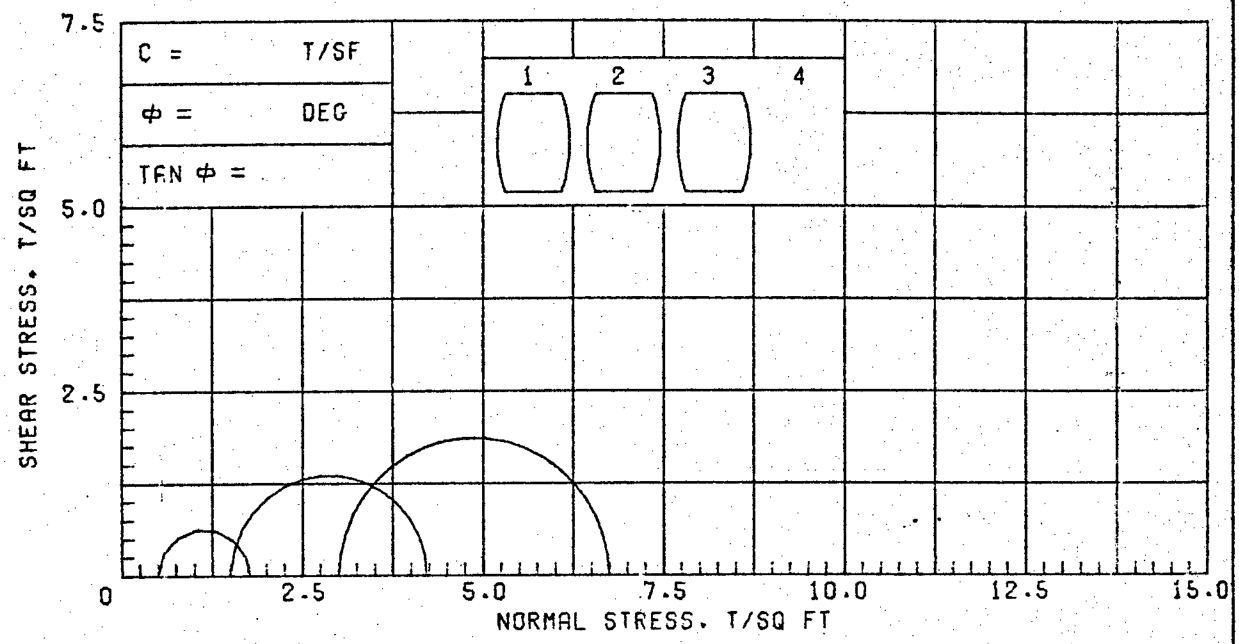
CONTROLLED-STRAIN TEST

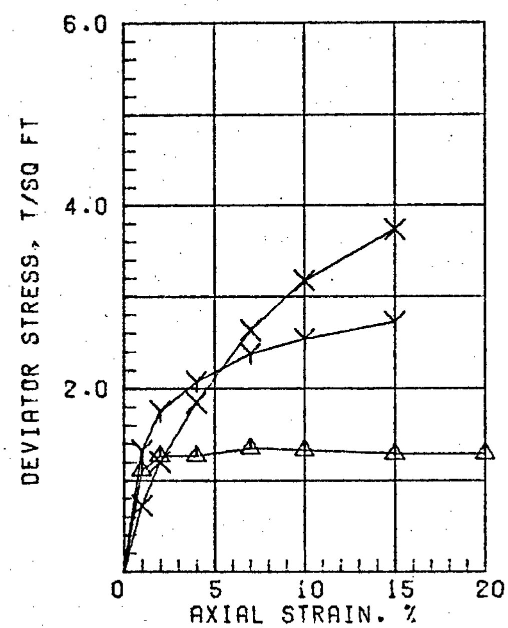
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC), BROWN

LL 30	PL 16	PI 14	GS 2.69	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 483-U	SAMPLE NO. 5
	DEPTH/ELEV 12.3-13.3	TECH. JAL
	LABORATORY USAE WES	DATE 28 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 55





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	12.8	12.4	11.7	
	DRY DENSITY, PCF	89.0	91.6	89.2	
	SATURATION, %	38.5	39.7	35.4	
	VOID RATIO	0.900	0.847	0.896	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	1.27	2.72	3.74	
	TIME TO FAILURE, MIN.	16	27	20	
	RATE OF STRAIN INCR.%	4			
	INITIAL DIAMETER, IN.	1.41	1.39	1.40	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

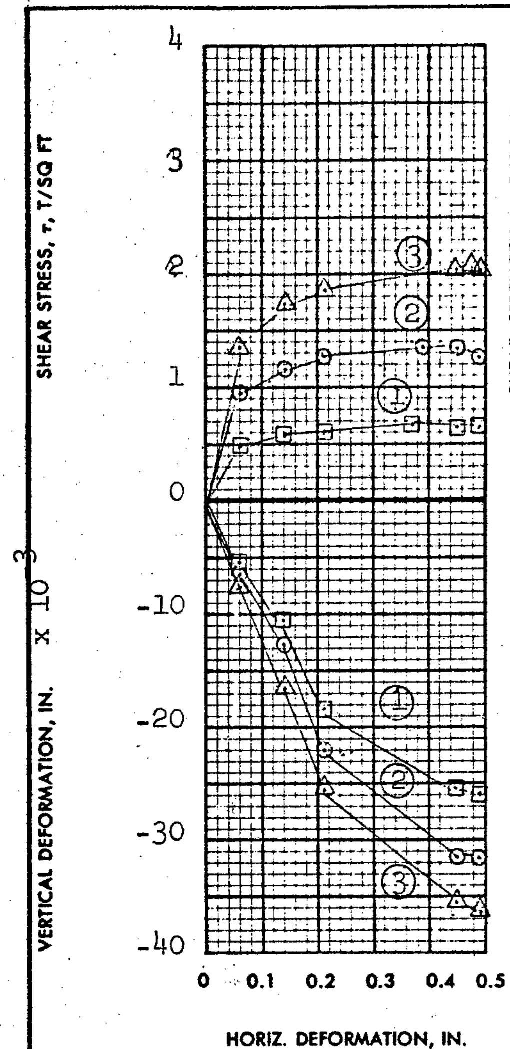
CONTROLLED-STRAIN TEST

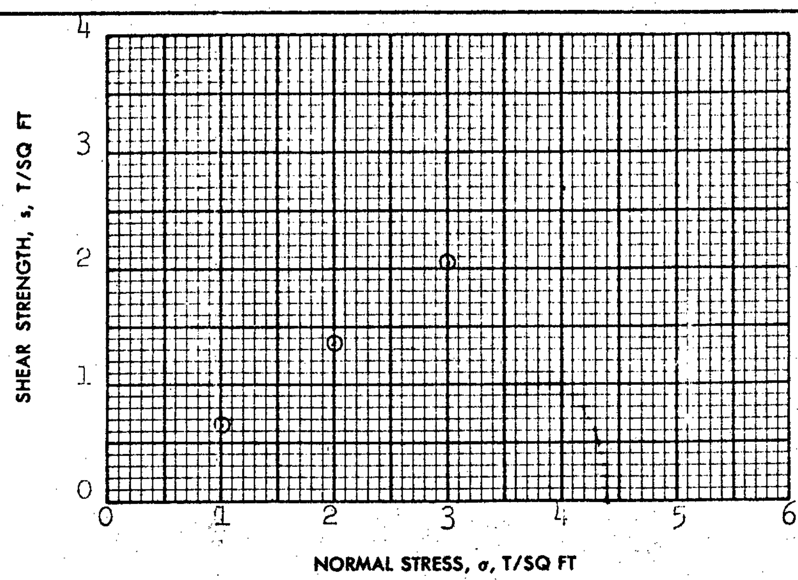
DESCRIPTION OF SPECIMENS: SANDY CLAY (CL), TAN; VERTICAL FISSURES

LL 29	PL 14	PI 15	GS 2.71	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 483-U	SAMPLE NO. 6
	DEPTH/ELEV 15.0-16.1	TECH. JAL
	LABORATORY USAE WES	DATE 30 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 56





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	15.5%	15.1%	15.0%	%
	VOID RATIO	e_o	0.695	0.752	0.730	
	SATURATION	S_o	28.9 %	29.5%	31.3%	%
	DRY DENSITY, LB/CU FT	γ_d	99.8	98.1	97.8	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	15.5%	15.1%	15.0%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.67	1.35	2.05	
ACTUAL TIME TO FAILURE, MIN		t_f	1200	1260	1530	
RATE OF STRAIN, IN./MIN			.00032	.00032	.00032	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN	UNDISTURBED		3.00 IN. SQUARE		0.457 IN. THICK
CLASSIFICATION	SANDY CLAY (CL), LIGHT BROWN				
LL 29	PL 14	PI 15			G_s 2.71

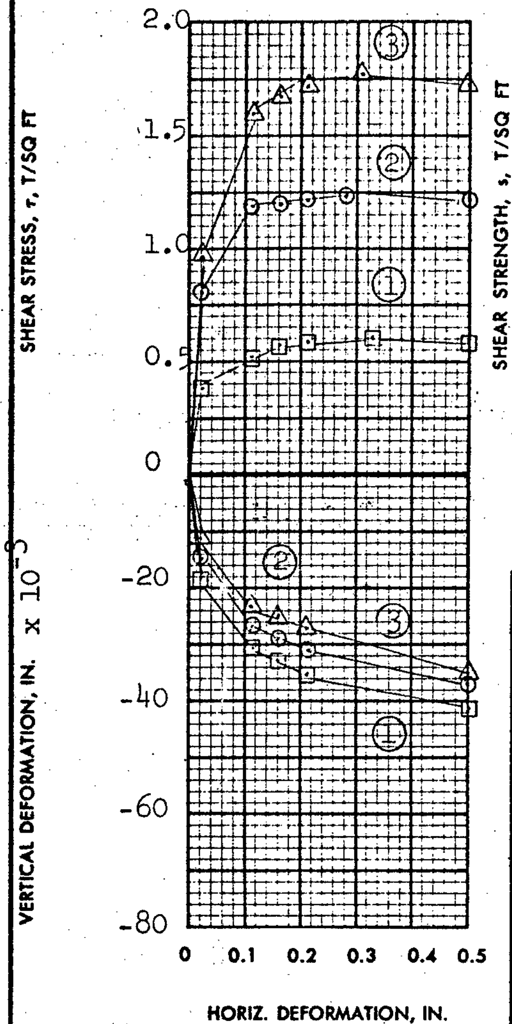
REMARKS ____________

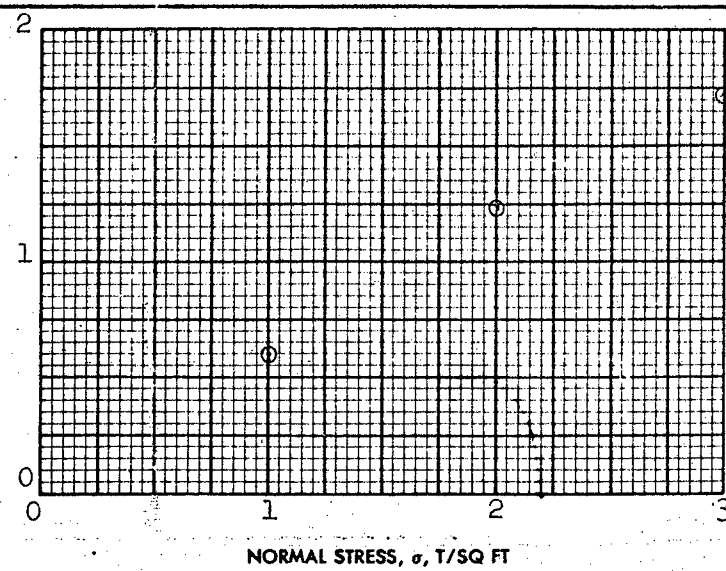
PROJECT DIKE STABILITY	
ROCKY MOUNTAIN ARSENAL	
AREA	
BORING NO. 483-U	SAMPLE NO. 7
DEPTH EL 16.1-17.1	DATE 02 APR 78
RCH	DIRECT SHEAR TEST REPORT

ENG FORM 1 JUN 65 2092 (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1966 OF—214-948

Figure 57





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	8.1 %	7.8 %	7.7 %	%
	VOID RATIO	e_o	0.898	0.902	0.928	
	SATURATION	S_o	24.6 %	23.6 %	22.6 %	%
	DRY DENSITY, LB/CU FT	γ_d	89.8	89.6	88.4	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	21.3 %	20.0 %	18.1 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.60	1.24	1.77	
ACTUAL TIME TO FAILURE, MIN		t_f	870	720	780	
RATE OF STRAIN, IN./MIN			.00036	.00036	.00036	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ______

TAN ϕ' = ______

c' = ______ T/SQ FT

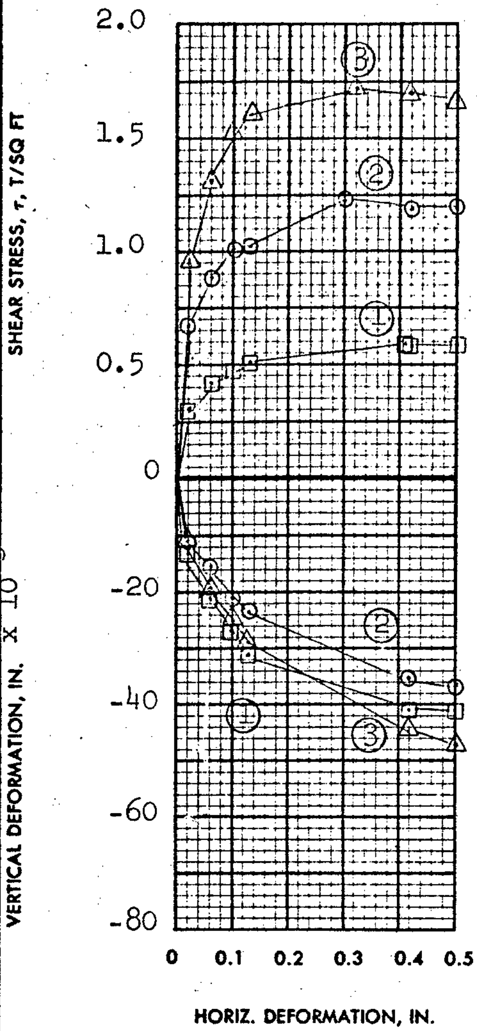
[ ] CONTROLLED STRESS

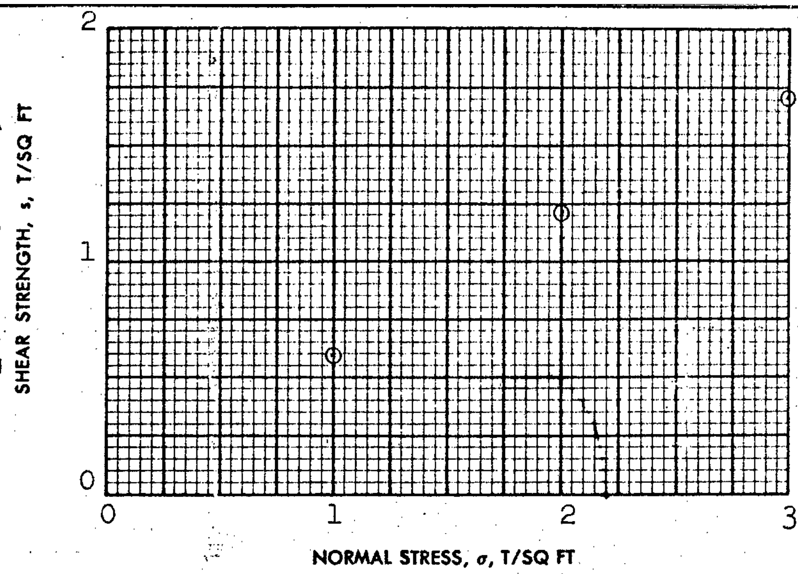
[x] CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED		3.00 IN. SQUARE	0.547 IN. THICK
CLASSIFICATION SANDY CLAY (CL), BROWN			
LL 40	PL 15	PI 25	G_s 2.73

REMARKS ______

PROJECT DIKE STABILITY	
ROCKY MOUNTAIN ARSENAL	
AREA	
BORING NO. 483-U	SAMPLE NO. 8
DEPTH EL 20.0-21.2	DATE 04 APR 78
RCH	**DIRECT SHEAR TEST REPORT**





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	8.3 %	8.2 %	8.3 %	%
	VOID RATIO	e_o	0.867	0.856	0.887	
	SATURATION	S_o	26.1 %	26.3%	25.5%	%
	DRY DENSITY, LB/CU FT	γ_d	91.3	91.8	90.3	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	3	<1	<1	
FINAL	WATER CONTENT	w_f	21.0%	18.0%	17.2%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.59	1.22	1.73	
ACTUAL TIME TO FAILURE, MIN		t_f	645	960	1020	
RATE OF STRAIN, IN./MIN			.00033	.00033	.00033	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ______________

TAN ϕ' = ______________

c' = ______________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN	UNDISTURBED	3.00 IN. SQUARE	0.547 IN. THICK
CLASSIFICATION	SANDY CLAY (CL), LIGHT BROWN		

LL 39	PL 17	PI 22		G_s 2.73

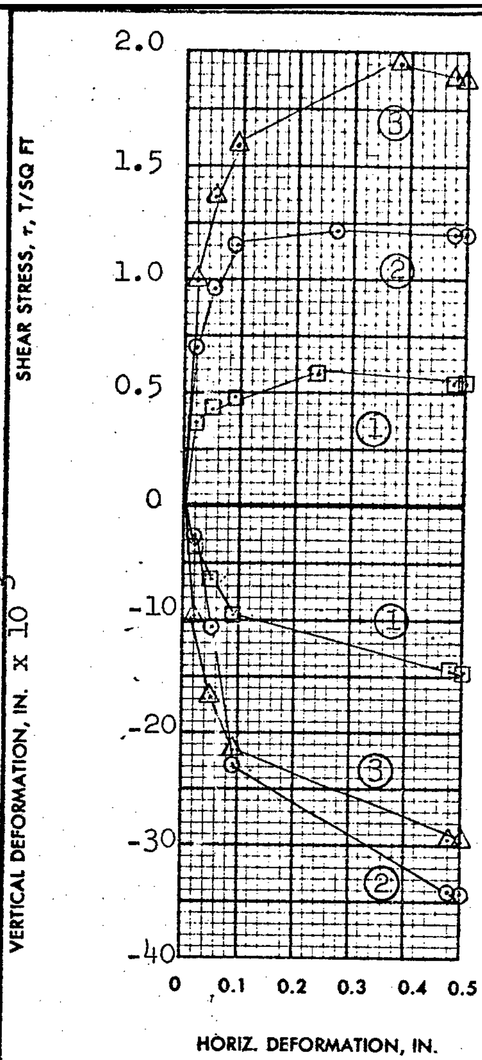
REMARKS ______________

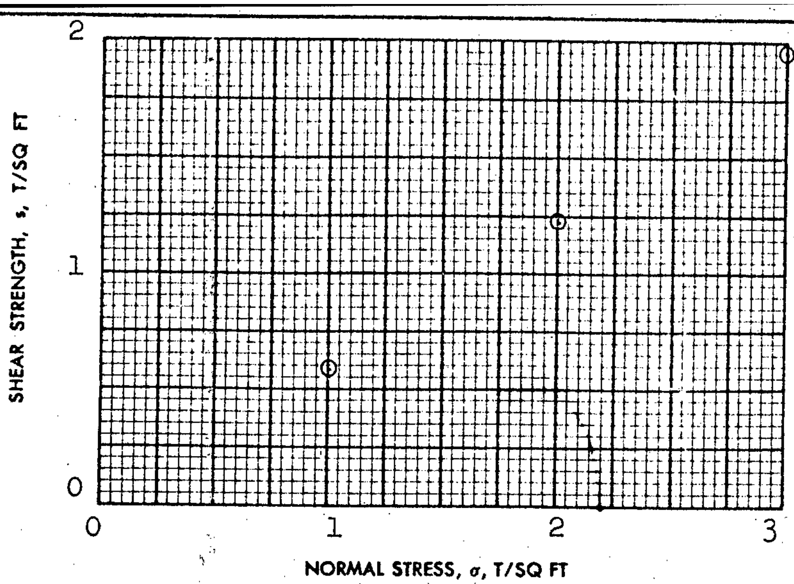
PROJECT	DIKE STABILITY
	ROCKY MOUNTAIN ARSENAL
AREA	
BORING NO. 483-U	SAMPLE NO. 9
DEPTH EL 21.2-22.0	DATE 05 APR 78
RCH	DIRECT SHEAR TEST REPORT

ENG FORM 1 JUN 65 **2092** *(EM 1110-2-1906)* PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1965 OF—214-945

Figure 59





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	6.5 %	6.5%	6.6%	%
	VOID RATIO	e_o	0.740	0.744	0.758	
	SATURATION	S_o	24.1 %	23.9 %	23.9 %	%
	DRY DENSITY, LB/CU FT	γ_d	98.3	98.1	97.3	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	5	3	3	
FINAL	WATER CONTENT	w_f	19.2 %	16.5%	15.1%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.58	1.22	1.95	
ACTUAL TIME TO FAILURE, MIN		t_f	660	720	990	
RATE OF STRAIN, IN./MIN			.00024	.00024	.00024	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED	3.00 IN. SQUARE	0.547 IN. THICK	
CLASSIFICATION SANDY CLAY (CL), BROWN			
LL 28	PL 16	PI 12	G_s 2.74

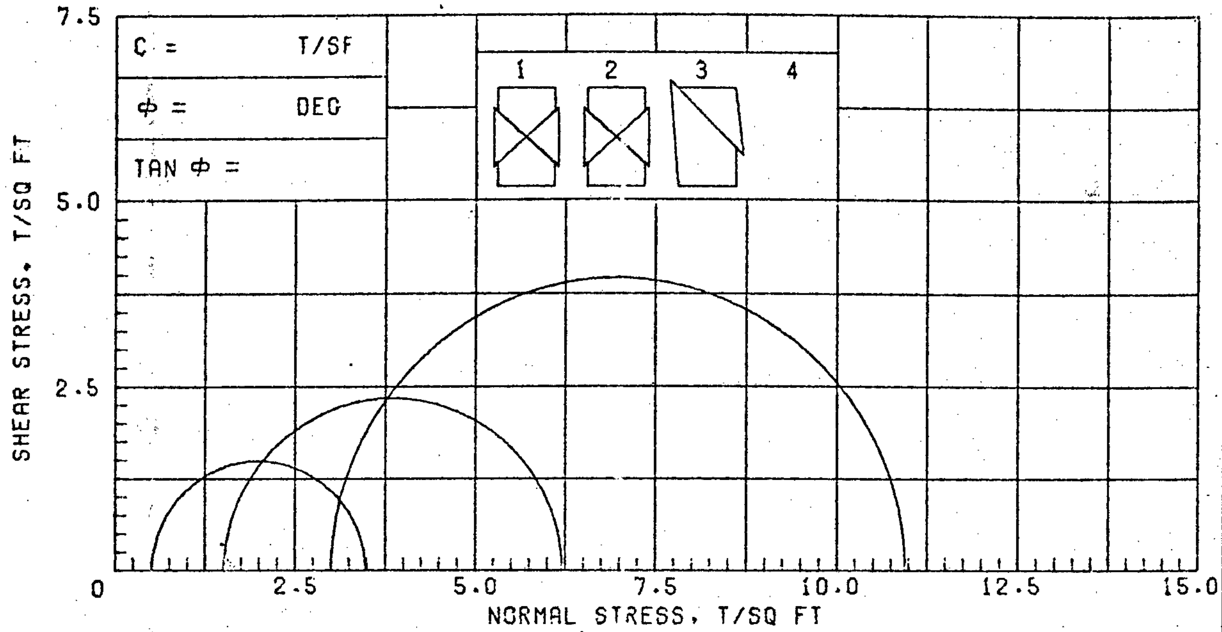
REMARKS ____________

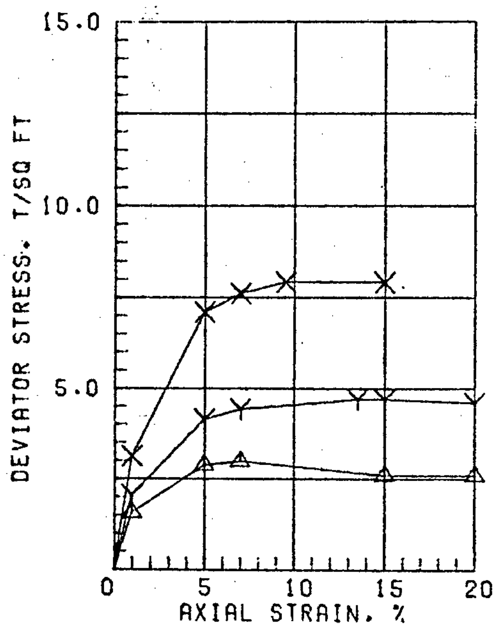
PROJECT DIKE STABILITY	
ROCKY MOUNTAIN ARSENAL	
AREA	
BORING NO. 483-U	SAMPLE NO. 10
DEPTH EL 25.0-26.3	DATE 05 APR 78
RCH	DIRECT SHEAR TEST REPORT

ENG FORM 1 JUN 65 **2092** *(EM 1110-2-1906)* PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1966 OF—214-948

Figure 60





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	10.7	11.6	10.9	
	DRY DENSITY, PCF	115.5	115.5	113.4	
	SATURATION, %	63.4	68.8	60.9	
	VOID RATIO	0.454	0.454	0.481	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		2.99	4.71	7.94	
TIME TO FAILURE, MIN.		22	28	20	
RATE OF STRAIN INCR.%					
INITIAL DIAMETER, IN.		1.40	1.41	1.41	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

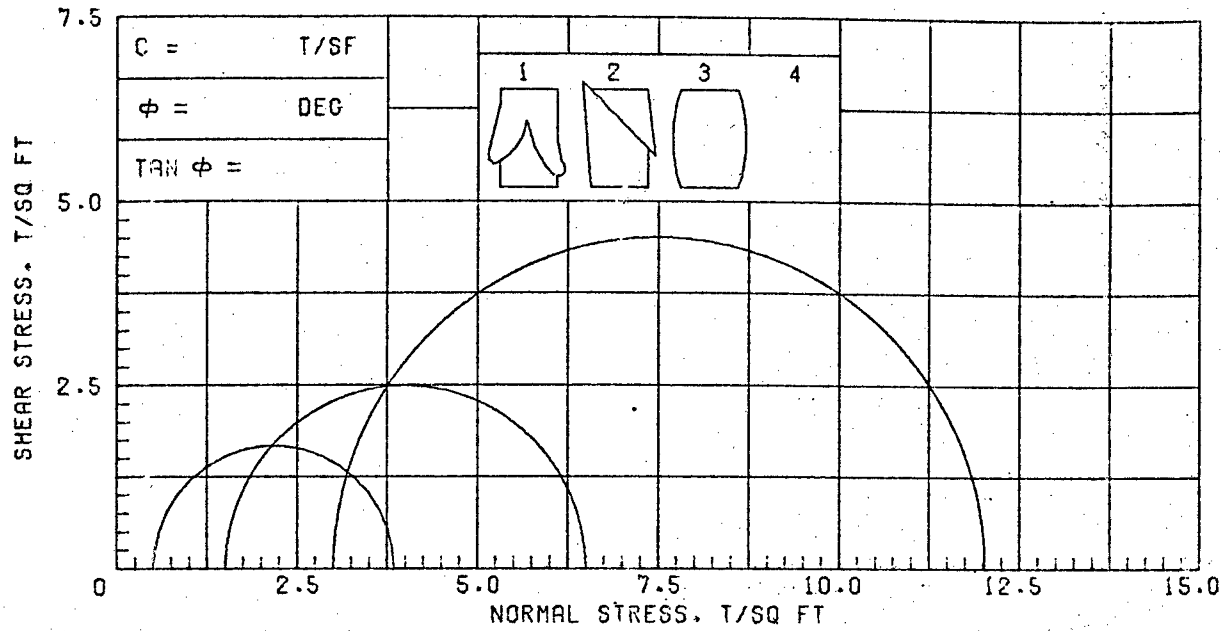
CONTROLLED-STRAIN TEST

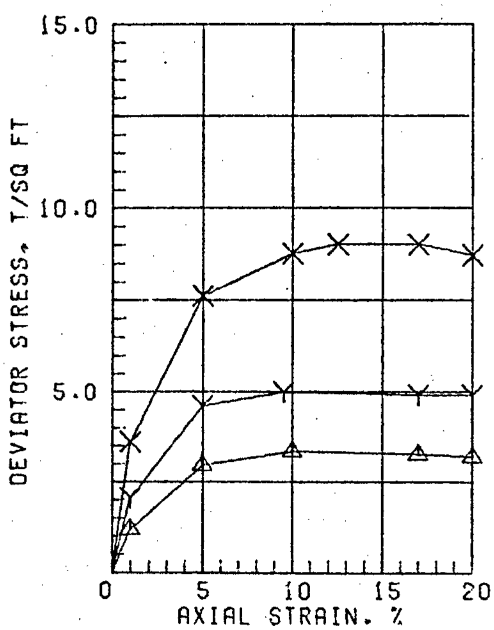
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC), TAN

LL 20	PL 13	PI 7	GS 2.69	UNDISTURBED SPECIMEN	Q TEST

REMARKS:		
	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 1
	DEPTH/ELEV 0.0-1.1	TECH. JAL
	LABORATORY USAE WES	DATE 28 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 61





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	11.7	11.1	10.8	
INITIAL	DRY DENSITY, PCF	115.5	114.2	115.8	
INITIAL	SATURATION, %	68.8	63.0	64.0	
INITIAL	VOID RATIO	0.459	0.476	0.456	
BEFORE SHEAR	WATER CONTENT, %				
BEFORE SHEAR	DRY DENSITY, PCF				
BEFORE SHEAR	SATURATION, %				
BEFORE SHEAR	VOID RATIO				
BEFORE SHEAR	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	3.35	5.00	9.02	
	TIME TO FAILURE, MIN.	28	19	25	
	RATE OF STRAIN INCR.%				
	INITIAL DIAMETER, IN.	1.40	1.40	1.41	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

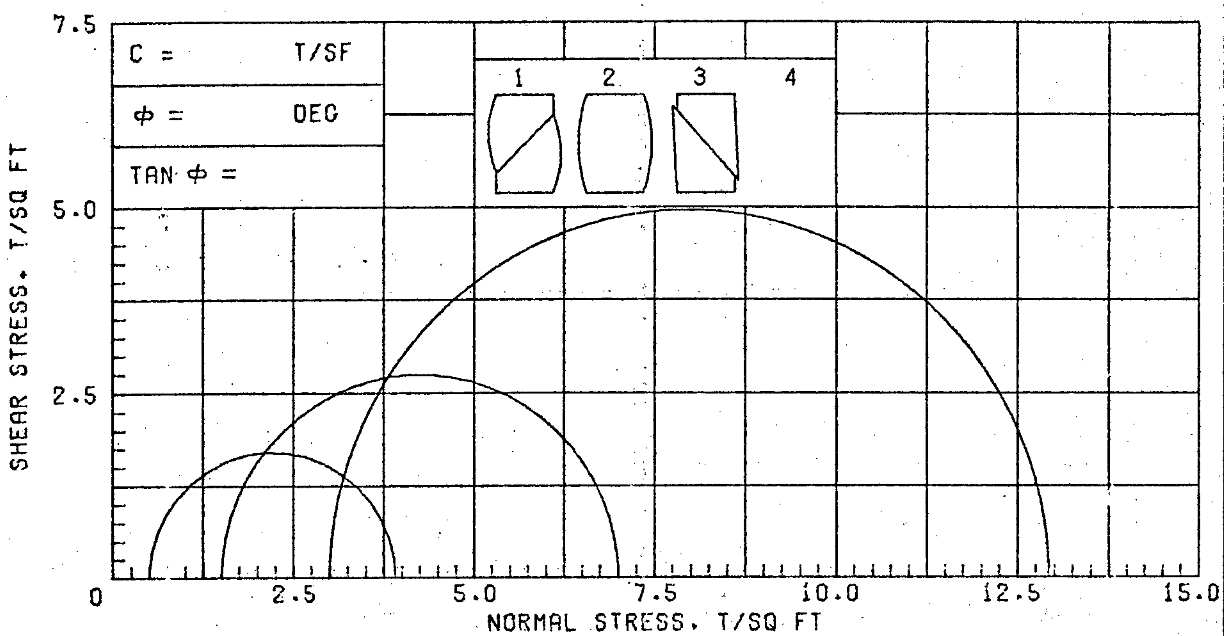
CONTROLLED-STRAIN TEST

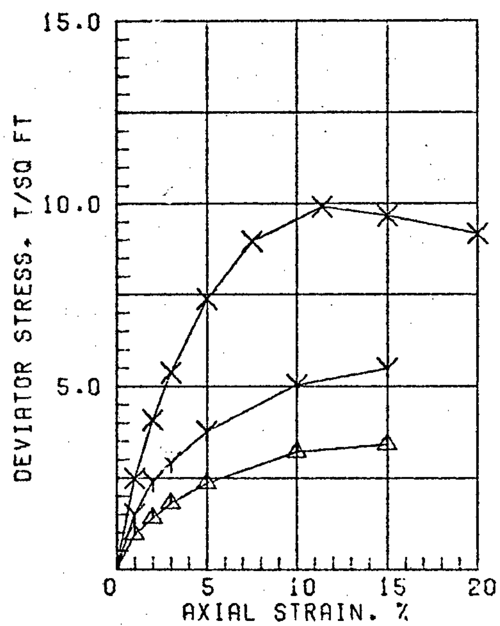
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC), TAN

LL 26	PL 13	PI 13	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 2
	DEPTH/ELEV 1.1-2.2	TECH. JAL
	LABORATORY USAE WES	DATE 29 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 62





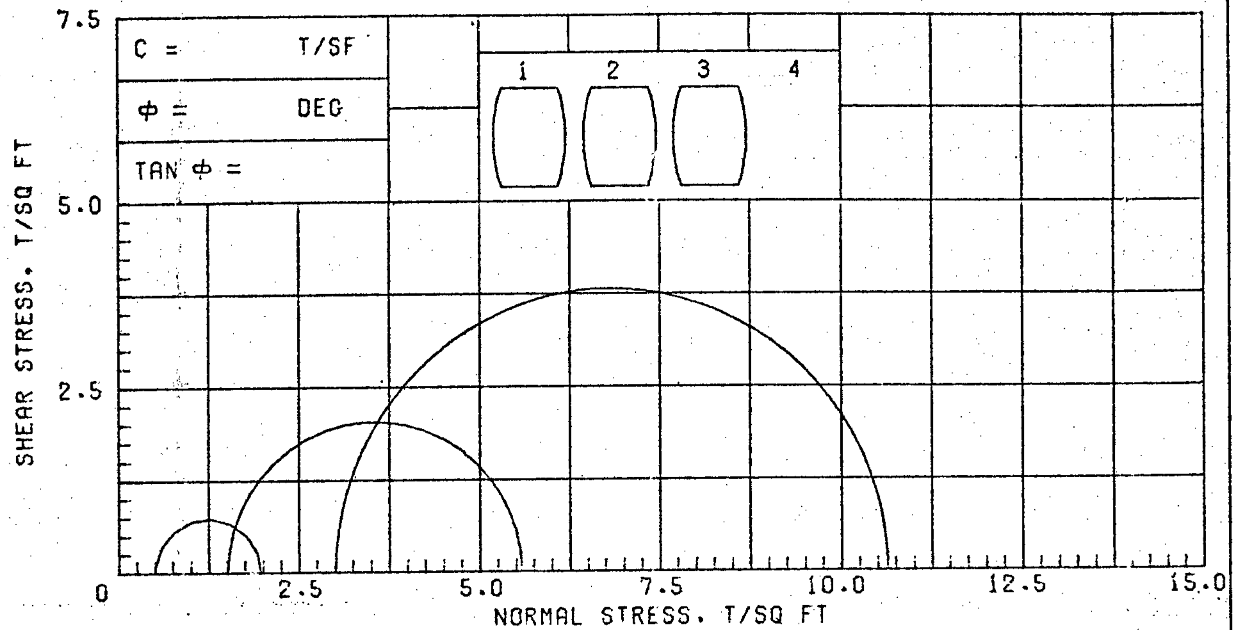
		SPECIMEN NO.	△1	Y2	X3	4
INITIAL		WATER CONTENT, %	11.7	11.3	11.3	
		DRY DENSITY, PCF	117.0	117.5	120.5	
		SATURATION, %	72.3	70.8	77.2	
		VOID RATIO	0.436	0.429	0.394	
BEFORE SHEAR		WATER CONTENT, %				
		DRY DENSITY, PCF				
		SATURATION, %				
		VOID RATIO				
		BACK PRESS., TSF				
MIN PRIN. STRESS, TSF			0.5	1.5	3.0	
MAX. DEV. STRESS, TSF			3.42	5.50	9.92	
TIME TO FAILURE, MIN.			36	36	27	
RATE OF STRAIN INCR.%						
INITIAL DIAMETER, IN.			1.40	1.39	1.40	
INITIAL HEIGHT, IN.			3.00	3.00	3.00	

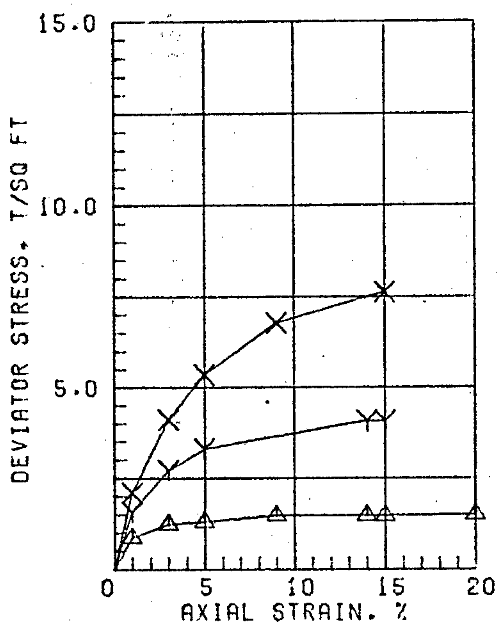
CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC), DARK BROWN					
LL 27	PL 11	PI 16	GS 2.69	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 3
	DEPTH/ELEV 5.0-5.9	TECH. RE
	LABORATORY USAE WES	DATE 28 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 63





SPECIMEN NO.		△1	Y2	X3	4
INITIAL	WATER CONTENT, %	7.4	7.0	7.0	
	DRY DENSITY, PCF	102.4	101.8	101.8	
	SATURATION, %	30.9	28.8	28.8	
	VOID RATIO	0.646	0.656	0.655	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		1.47	4.08	7.63	
TIME TO FAILURE, MIN.		21	30	19	
RATE OF STRAIN INCR.%					
INITIAL DIAMETER, IN.		1.39	1.39	1.39	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

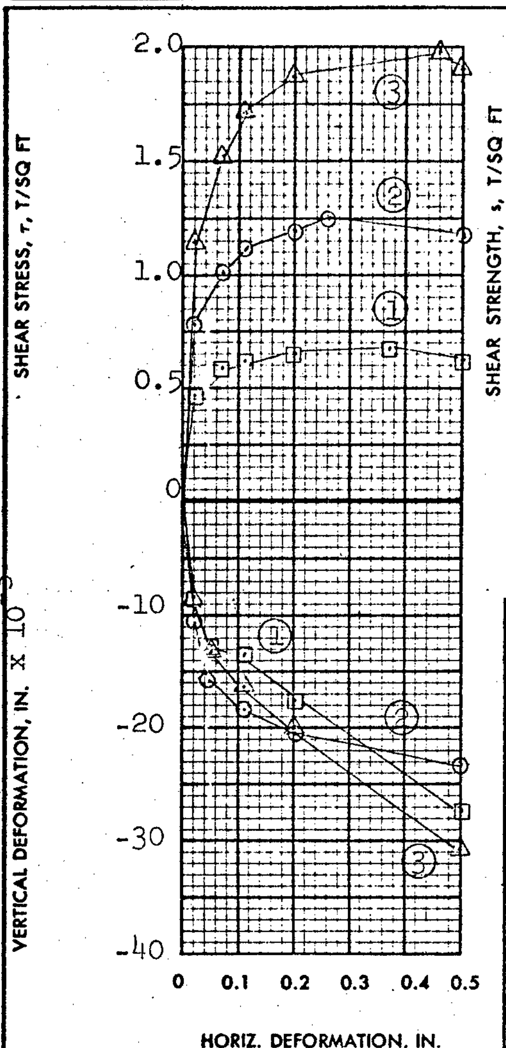
DESCRIPTION OF SPECIMENS: SILTY SAND (SM), TAN; A FEW CARBONATE CONCRETIONS UP TO 1/4"

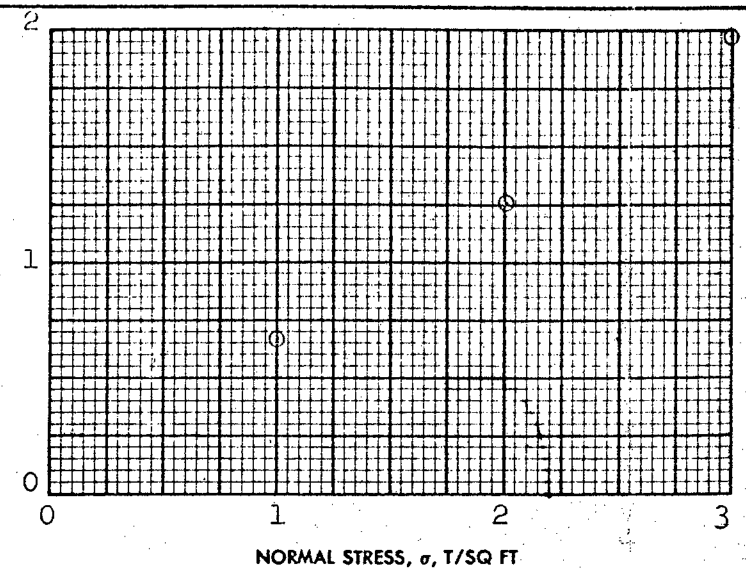
LL	PL	PI	GS 2.70	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY ROCKY MOUNTAIN ARSENAL
BORING NO. 484-U	SAMPLE NO. 4
DEPTH/ELEV 10.0-11.1	TECH. JAL
LABORATORY USAE WES	DATE 31 MAR 78

TRIAXIAL COMPRESSION TEST REPORT

Figure 64





SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	7.6 %	7.8 %	7.5 %	%
	VOID RATIO	e_o	0.589	0.596	0.586	
	SATURATION	S_o	34.8 %	35.3 %	34.6 %	%
	DRY DENSITY, LB/CU FT	γ_d	106.1	105.6	106.3	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	13.8 %	13.4 %	13.9 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.67	1.25	1.98	
ACTUAL TIME TO FAILURE, MIN		t_f	1020	750	1230	
RATE OF STRAIN, IN./MIN			.00039	.00039	.00039	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

TYPE OF SPECIMEN UNDISTURBED — 3.00 IN. SQUARE — 0.547 IN. THICK

CLASSIFICATION SILTY SAND (SM), BROWN

LL NP — PL NP — PI NP — G_s 2.70

REMARKS

PROJECT DIKE STABILITY
ROCKY MOUNTAIN ARSENAL

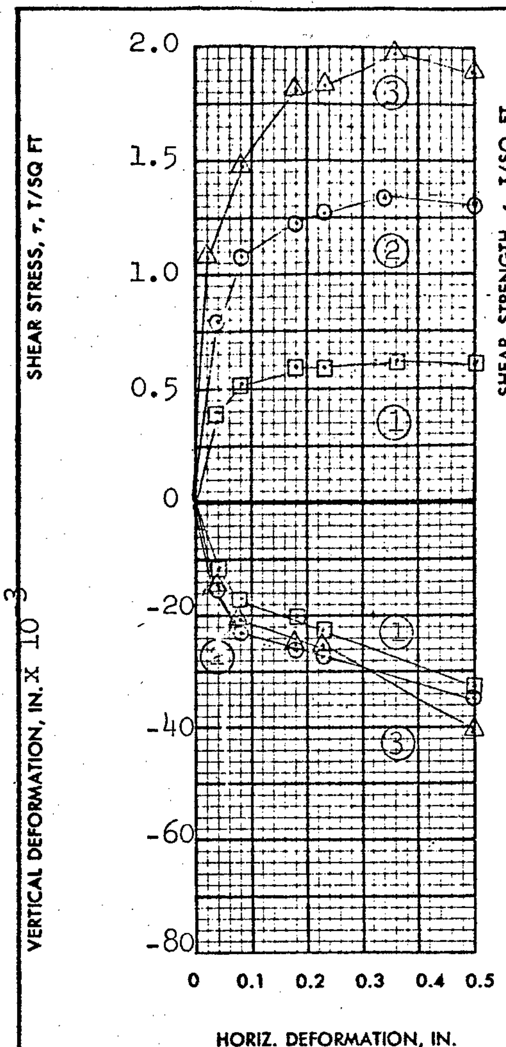
AREA

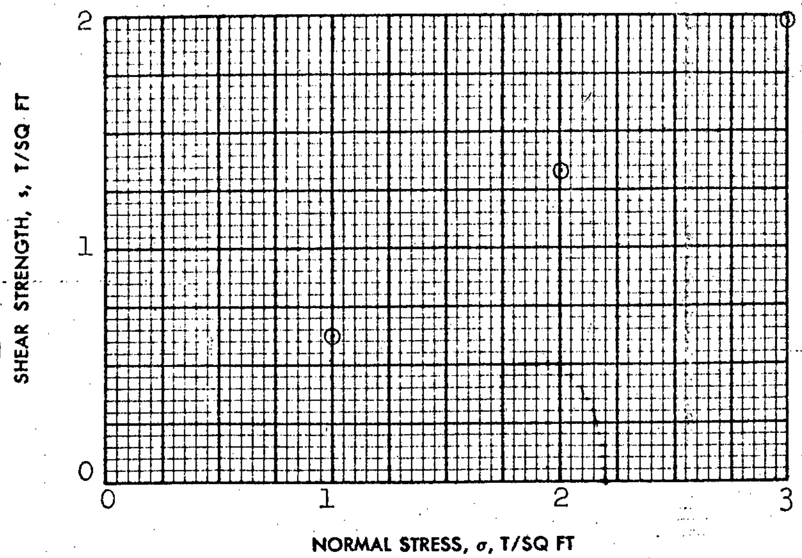
BORING NO. 484-U — SAMPLE NO. 5

DEPTH EL 11.1-12.2 — DATE 06 APR 78

RCH **DIRECT SHEAR TEST REPORT**

Figure 65





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	10.3 %	10.7 %	11.0%	%
	VOID RATIO	e_o	0.795	0.793	0.803	
	SATURATION	S_o	35.5%	37.0%	37.5 %	%
	DRY DENSITY, LB/CU FT	γ_d	95.3	95.4	94.9	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	16.2%	15.4%	15.0%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.63	1.34	1.98	
ACTUAL TIME TO FAILURE, MIN		t_f	900	870	900	
RATE OF STRAIN, IN./MIN			.00039	.00039	.00039	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

φ' = ______________

TAN φ' = ______________

c' = ______________ T/SQ FT

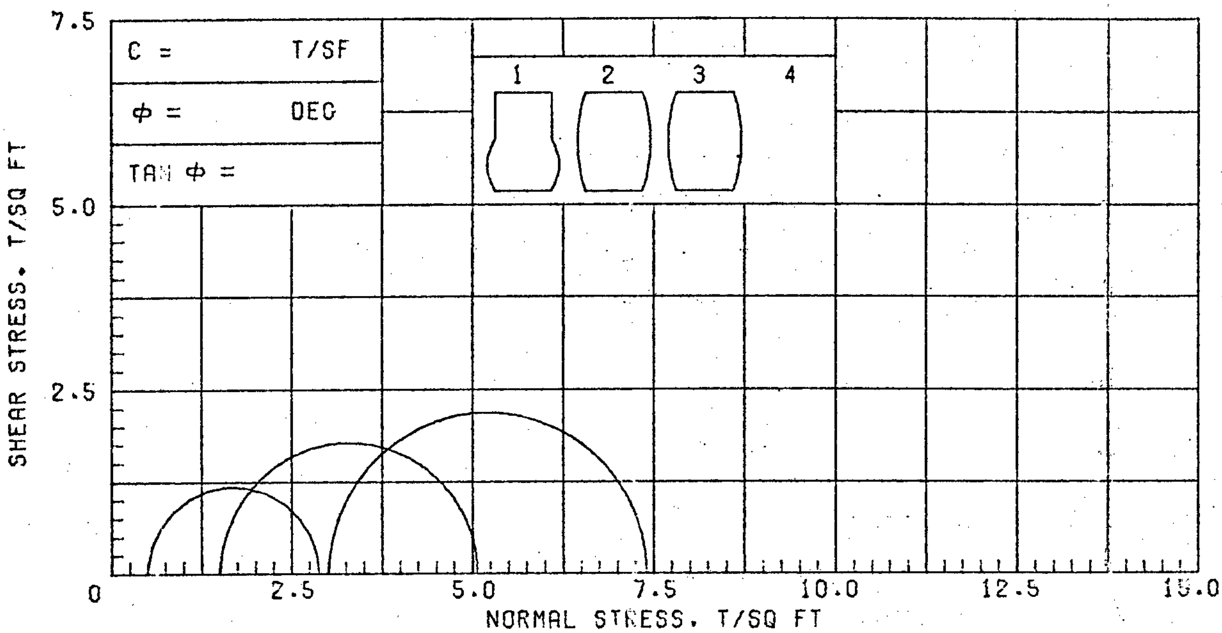
☐ CONTROLLED STRESS

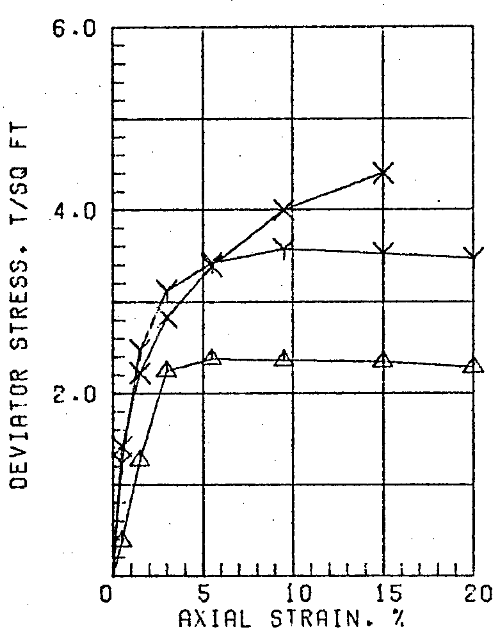
☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED		3.00 IN. SQUARE	0.547 IN. THICK
CLASSIFICATION CLAYEY SAND (SC), BROWN			
LL 26	PL 11	PI 15	G_s 2.74

REMARKS ______________

PROJECT	DIKE STABILITY ROCKY MOUNTAIN ARSENAL	
AREA		
BORING NO.	484-U	SAMPLE NO. 6
DEPTH EL	15.0-16.1	DATE 07 APR 78
RCH	DIRECT SHEAR TEST REPORT	





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	27.8	24.6	28.6	
	DRY DENSITY, PCF	81.3	86.6	86.4	
	SATURATION, %	68.9	69.2	79.9	
	VOID RATIO	1.105	0.975	0.980	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		2.38	3.57	4.40	
TIME TO FAILURE, MIN.		21	13	22	
RATE OF STRAIN INCR.%		01			
INITIAL DIAMETER, IN.		1.40	1.41	1.39	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

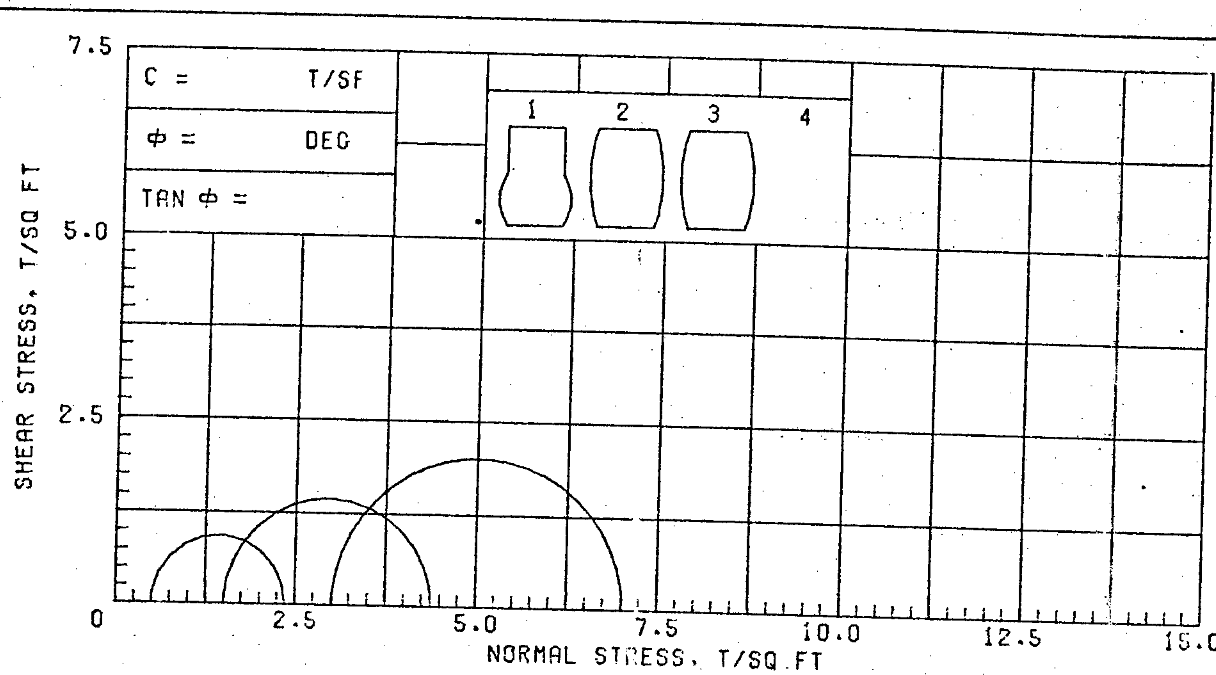
CONTROLLED-STRAIN TEST

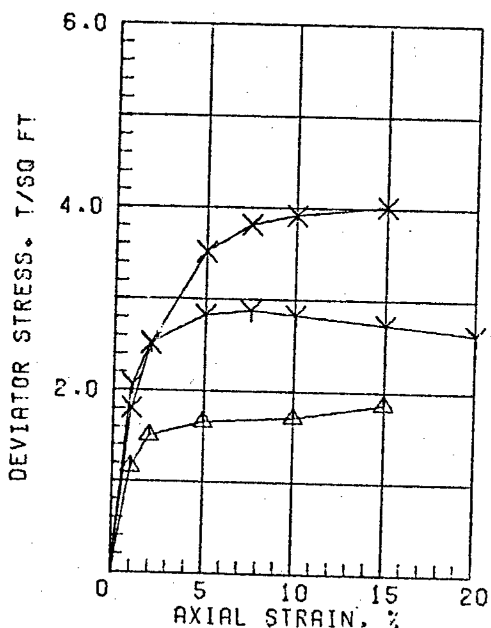
DESCRIPTION OF SPECIMENS; CLAYEY SAND (SC), TAN; SAND IN UNUSED PORTIONS OF SAMPLE

LL 44	PL 16	PI 28	GS 2.74	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 7
	DEPTH/ELEV 16.1-16.9	TECH. CR
	LABORATORY USAE WES	DATE 28 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 67





SPECIMEN NO.		Δ1	Y2	X3	4
INITIAL	WATER CONTENT, %	17.7	19.3	17.9	
	DRY DENSITY, PCF	95.2	93.5	97.6	
	SATURATION, %	61.4	64.3	65.8	
	VOID RATIO	0.784	0.816	0.740	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		1.87	2.88	4.02	
TIME TO FAILURE, MIN.		37	19	39	
RATE OF STRAIN INCR.,%					
INITIAL DIAMETER, IN.		1.39	1.39	1.40	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS: SANDY CLAY (CL)
LIGHT BROWN

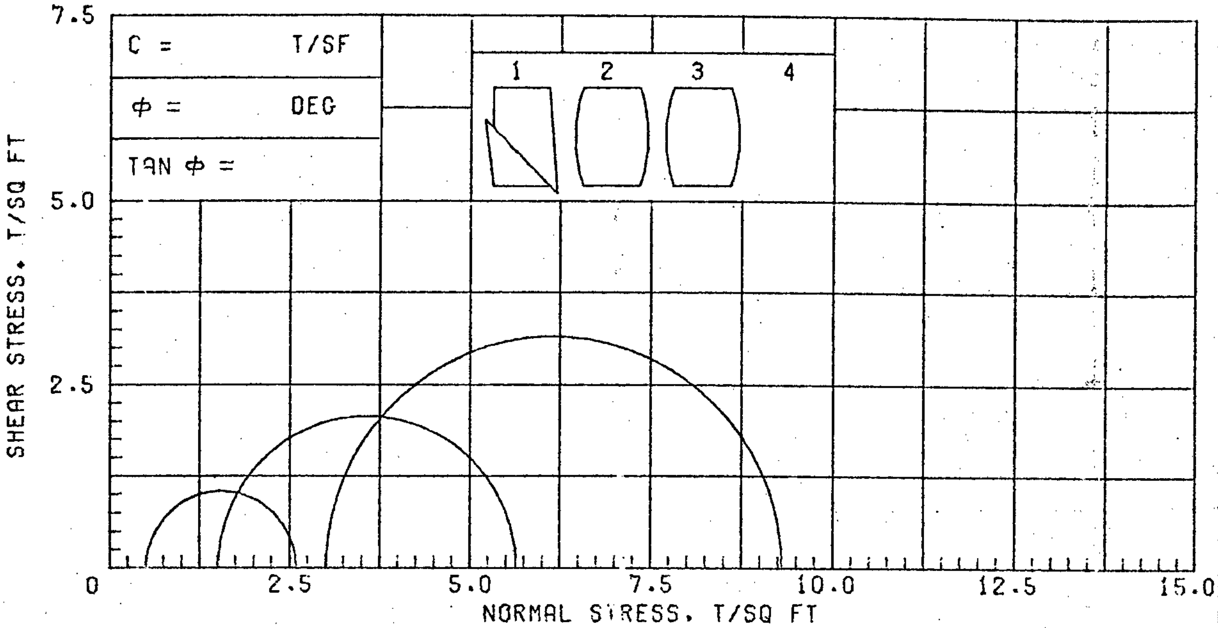
LL 32	PL 15	PI 17	GS 2.72	UNDISTURBED SPECIMEN	Q TEST

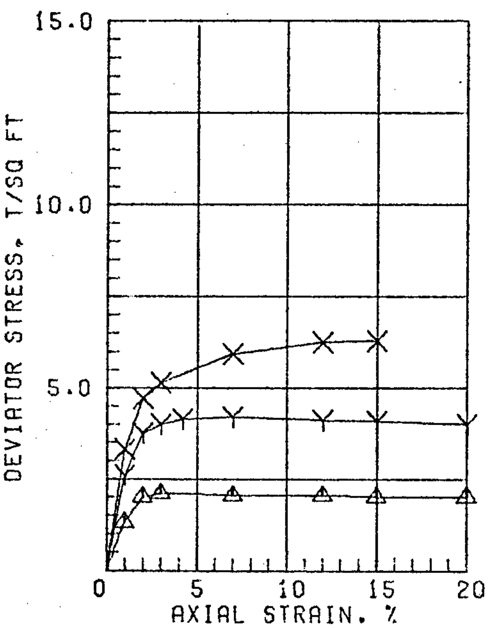
REMARKS:

PROJECT DIKE STABILITY	
ROCKY MOUNTAIN ARSENAL	
BORING NO. 484-U	SAMPLE NO. 8
DEPTH/ELEV 20.0-21.1	TECH. RE
LABORATORY USAE WES	DATE 29 MAR 78

TRIAXIAL COMPRESSION TEST REPORT

Figure 68





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	10.0	10.7	10.9	
	DRY DENSITY, PCF	109.1	107.1	104.4	
	SATURATION, %	48.9	49.8	47.3	
	VOID RATIO	0.556	0.585	0.626	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	2.10	4.14	6.30	
	TIME TO FAILURE, MIN.	15	21	29	
	RATE OF STRAIN INCR.,%	5	6		
	INITIAL DIAMETER, IN.	1.39	1.40	1.40	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

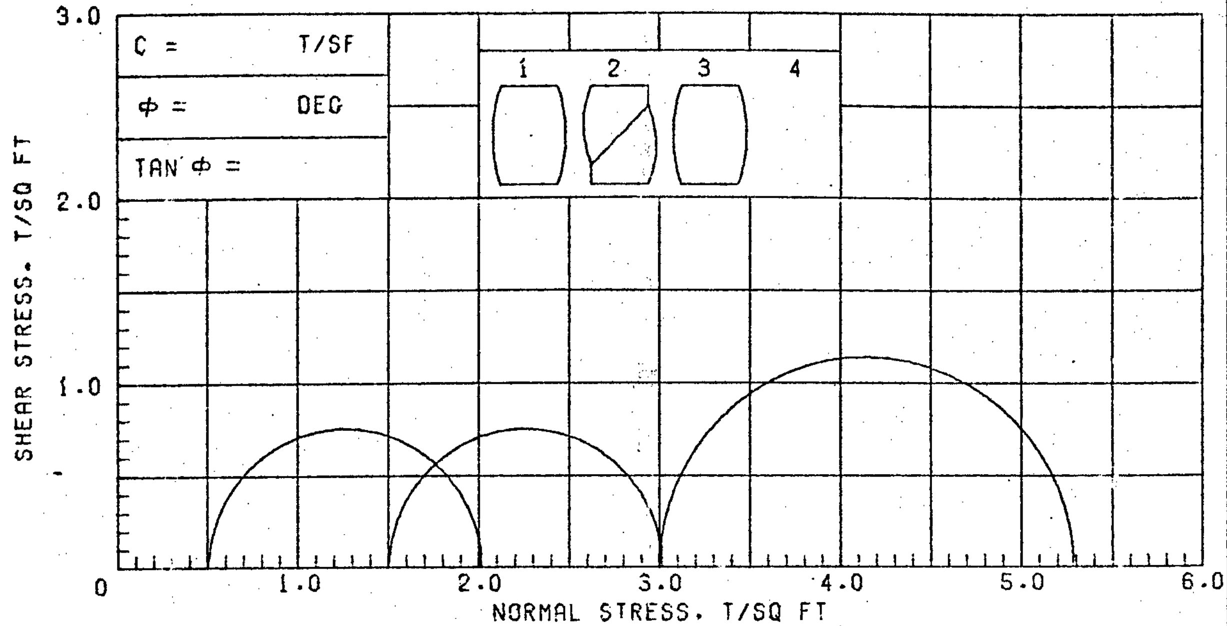
CONTROLLED-STRAIN TEST

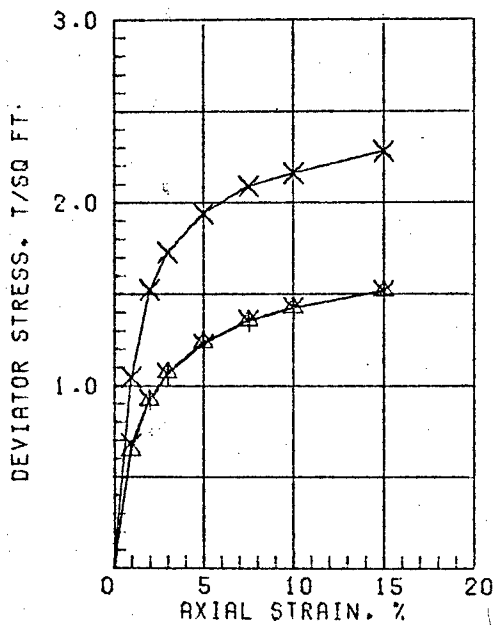
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC),
LIGHT BROWN

LL 24	PL 12	PI 12	GS 2.72	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 9
	DEPTH/ELEV 21.1-22.2	TECH. JAL
	LABORATORY USAE WES	DATE 29 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 69





		△1	Y2	X3	4
SPECIMEN NO.		△1	Y2	X3	4
INITIAL	WATER CONTENT, %	14.8	15.0	13.1	
	DRY DENSITY, PCF	114.1	112.1	116.4	
	SATURATION, %	81.8	78.7	77.1	
	VOID RATIO	0.494	0.520	0.464	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
MIN PRIN. STRESS, TSF		0.5	1.5	3.0	
MAX. DEV. STRESS, TSF		1.52	1.52	2.28	
TIME TO FAILURE, MIN.		46	45	36	
RATE OF STRAIN INCR,%					
INITIAL DIAMETER, IN.		1.39	1.40	1.39	
INITIAL HEIGHT, IN.		3.00	3.00	3.00	

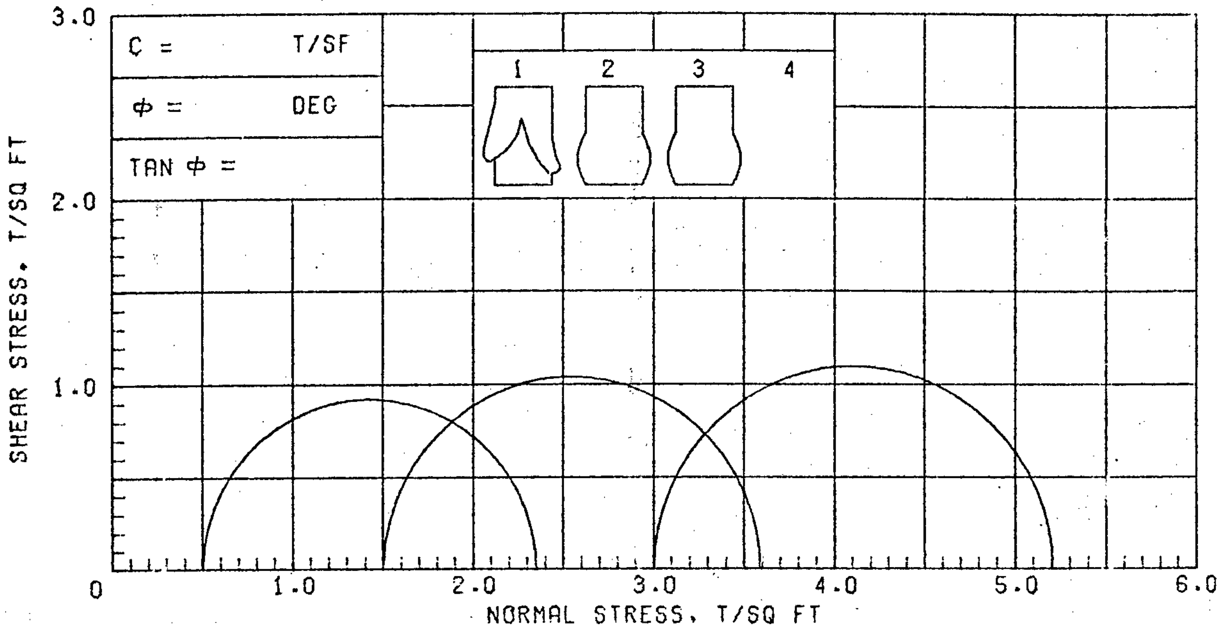
CONTROLLED-STRAIN TEST

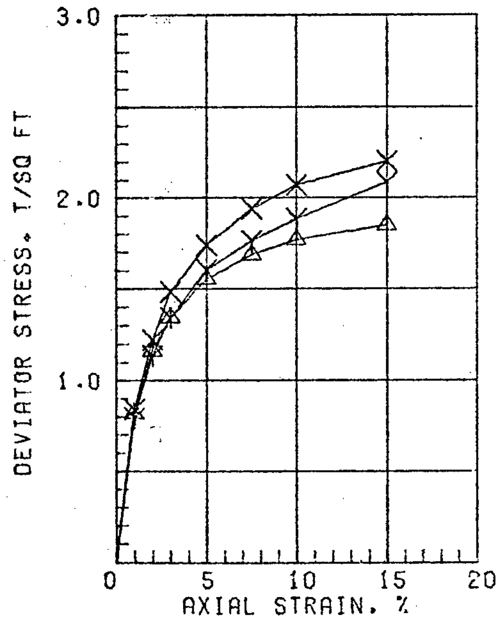
DESCRIPTION OF SPECIMENS: CLAYEY SAND (SC), LIGHT BROWN

LL 30	PL 13	PI 17	GS 2.73	UNDISTURBED SPECIMEN	Q TEST

REMARKS:	PROJECT DIKE STABILITY	
	ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 10
	DEPTH/ELEV 25.0-26.0	TECH. RE
	LABORATORY USAE WES	DATE 29 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 70





	SPECIMEN NO.	△1	Y2	X3	4
INITIAL	WATER CONTENT, %	21.0	20.2	20.1	
	DRY DENSITY, PCF	100.6	101.3	101.6	
	SATURATION, %	83.0	80.8	81.0	
	VOID RATIO	0.691	0.682	0.678	
BEFORE SHEAR	WATER CONTENT, %				
	DRY DENSITY, PCF				
	SATURATION, %				
	VOID RATIO				
	BACK PRESS., TSF				
	MIN PRIN. STRESS, TSF	0.5	1.5	3.0	
	MAX. DEV. STRESS, TSF	1.85	2.09	2.20	
	TIME TO FAILURE, MIN.	40	42	43	
	RATE OF STRAIN INCR,%				
	INITIAL DIAMETER, IN.	1.40	1.40	1.40	
	INITIAL HEIGHT, IN.	3.00	3.00	3.00	

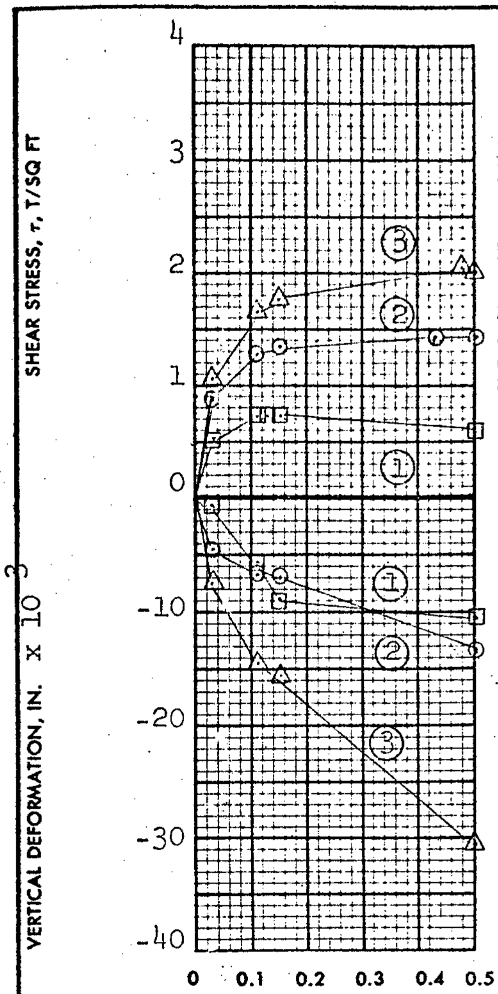
CONTROLLED-STRAIN TEST

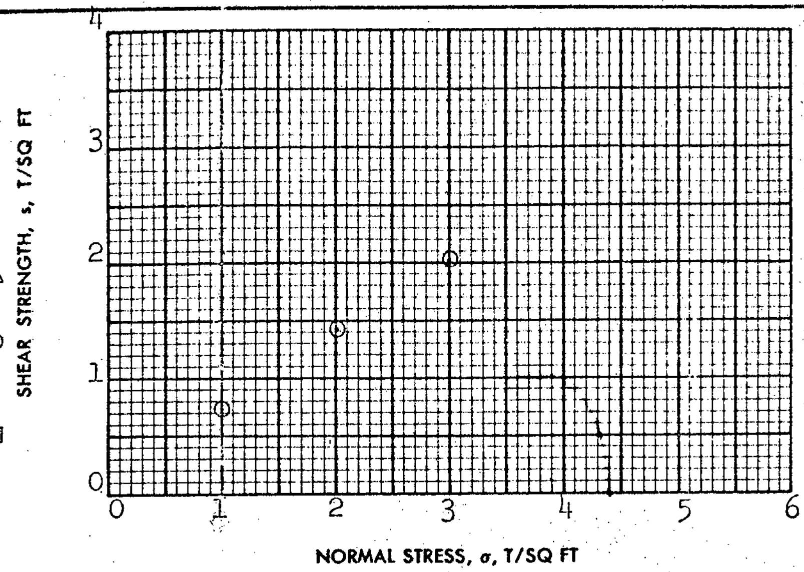
DESCRIPTION OF SPECIMENS; SANDY CLAY (CL), BROWN; WITH SMALL GYPSUM OR CARBONATE LENSES

LL 43	PL 18	PI 25	GS 2.73	UNDISTURBED SPECIMEN	Q TEST

REMARKS;	PROJECT DIKE STABILITY ROCKY MOUNTAIN ARSENAL	
	BORING NO. 484-U	SAMPLE NO. 11
	DEPTH/ELEV 26.0-27.0	TECH. RE
	LABORATORY USAE WES	DATE 30 MAR 78
	TRIAXIAL COMPRESSION TEST REPORT	

Figure 71





SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	10.1%	9.4 %	9.1 %	%
	VOID RATIO	e_o	0.587	0.575	0.574	
	SATURATION	S_o	46.5%	44.1%	19.3 %	%
	DRY DENSITY, LB/CU FT	γ_d	106.2	107.0	107.1	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	15.4%	15.5%	14.5 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.72	1.42	2.02	
ACTUAL TIME TO FAILURE, MIN		t_f	420	1230	1380	
RATE OF STRAIN, IN./MIN			.00035	.00035	.00035	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

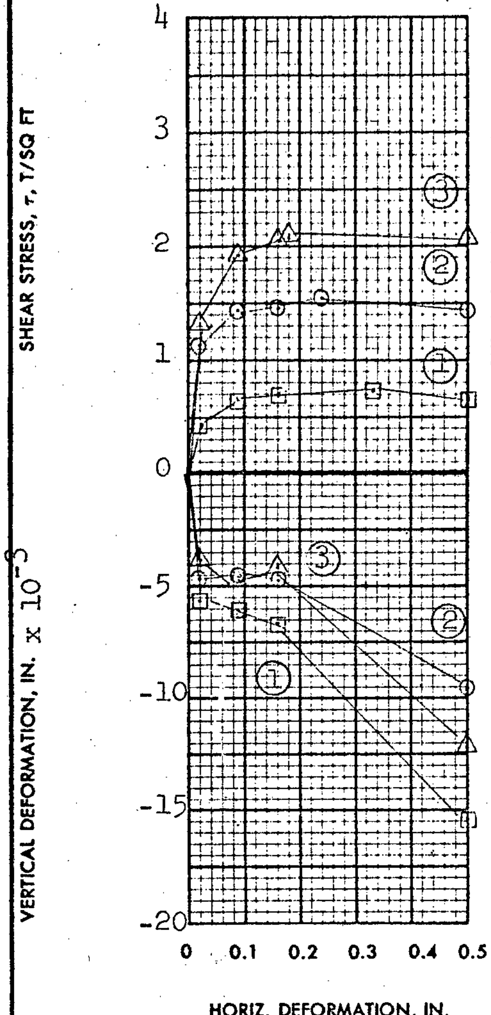
TYPE OF SPECIMEN	UNDISTURBED	3.00 IN. SQUARE	0.457 IN. THICK
CLASSIFICATION	SILTY SAND (SM), BROWN		

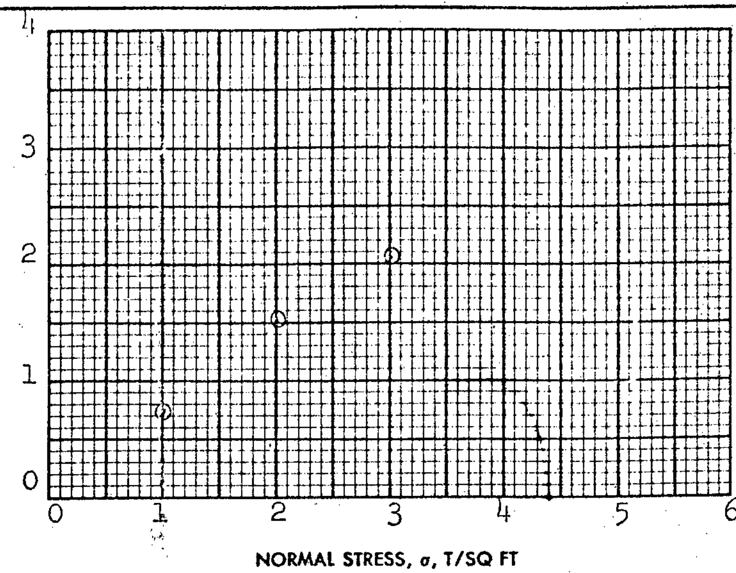
LL 19	PL 15	PI 4		G_s 2.70

REMARKS ____________

PROJECT	DIKE STABILITY
	ROCKY MOUNTAIN ARSENAL
AREA	
BORING NO. 485-U	SAMPLE NO. 1
DEPTH EL 0.0-1.3	DATE 07 APR 78
RCH	**DIRECT SHEAR TEST REPORT**

Figure 72





SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	8.8 %	9.8 %	9.1 %	%
	VOID RATIO	e_o	0.467	0.467	0.472	
	SATURATION	S_o	50.9 %	56.6 %	52.0 %	%
	DRY DENSITY, LB/CU FT	γ_d	114.9	114.9	114.5	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	14.3 %	14.8 %	14.6 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.73	1.51	2.06	
ACTUAL TIME TO FAILURE, MIN		t_f	870	660	510	
RATE OF STRAIN, IN./MIN			.00038	.00038	.00038	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

TYPE OF SPECIMEN UNDISTURBED	3.00 IN. SQUARE	0.544 IN. THICK	
CLASSIFICATION SILTY SAND (SM), BROWN			
LL 18	PL 14	PI 4	G_s 2.70

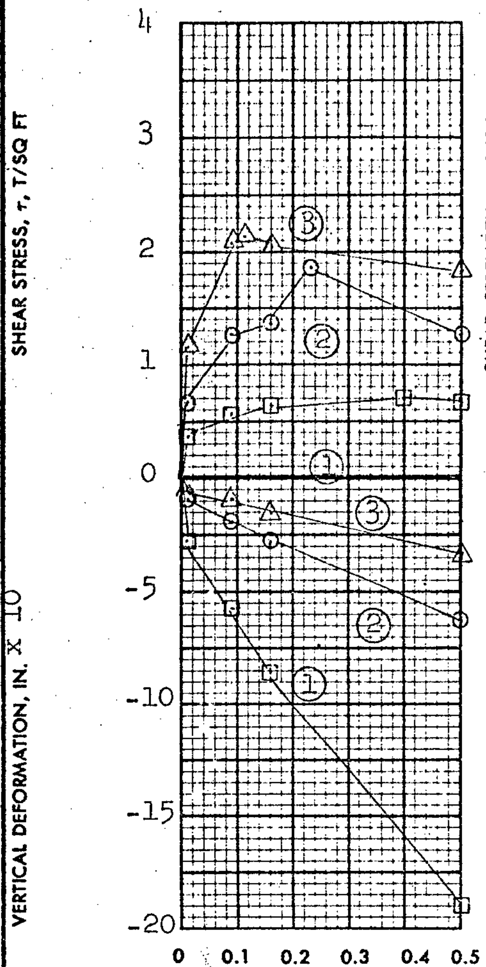
REMARKS ____________

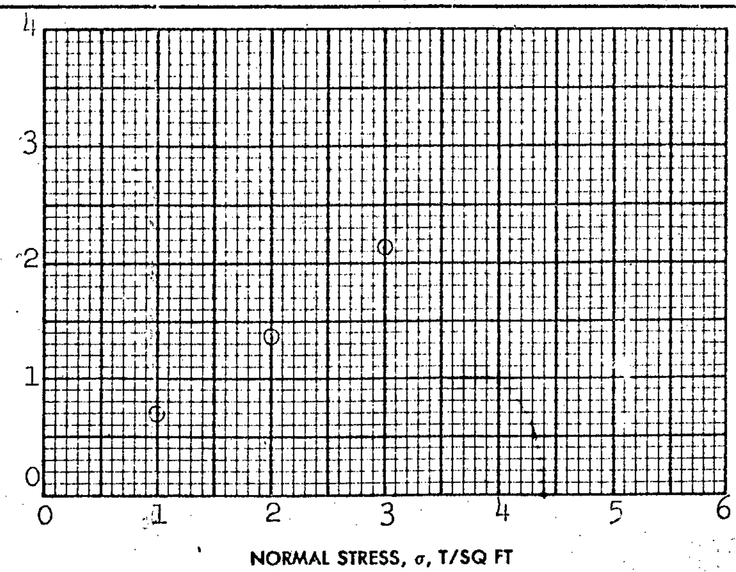
PROJECT DIKE STABILITY ROCKY MOUNTAIN ARSENAL	
AREA	
BORING NO. 485-U	SAMPLE NO. 2
DEPTH EL 5.0-6.0	DATE 08 APR 78
RCH	**DIRECT SHEAR TEST REPORT**

ENG FORM 1 JUN 65 **2092** *(EM 1110-2-1906)* PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1966 OF—214-945

Figure 73





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	13.0%	12.9 %	13.0 %	%
	VOID RATIO	e_o	0.497	0.500	0.504	
	SATURATION	S_o	70.6 %	70.0 %	69.6 %	%
	DRY DENSITY, LB/CU FT	γ_d	112.6	112.3	112.1	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	14.9%	14.6%	15.0%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.70	1.38	2.11	
ACTUAL TIME TO FAILURE, MIN		t_f	1050	630	360	
RATE OF STRAIN, IN./MIN			.00040	.00040	.00040	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

φ' = ______

TAN φ' = ______

c' = ______ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED 3.00 IN. SQUARE 0.544 IN. THICK

CLASSIFICATION SILTY SAND (SM), BROWN

LL 20 PL 16 PI 4 G_s 2.70

REMARKS ______

PROJECT DIKE STABILITY

ROCKY MOUNTAIN ARSENAL

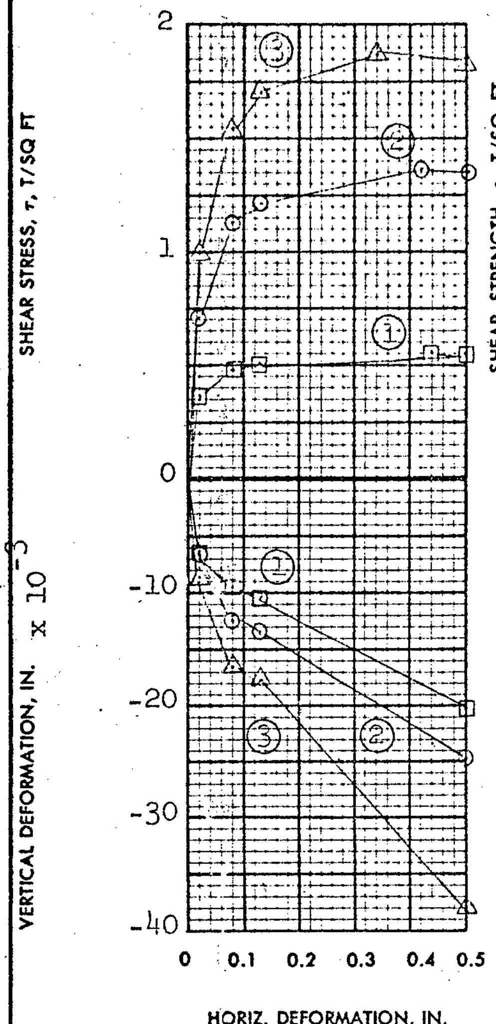
AREA

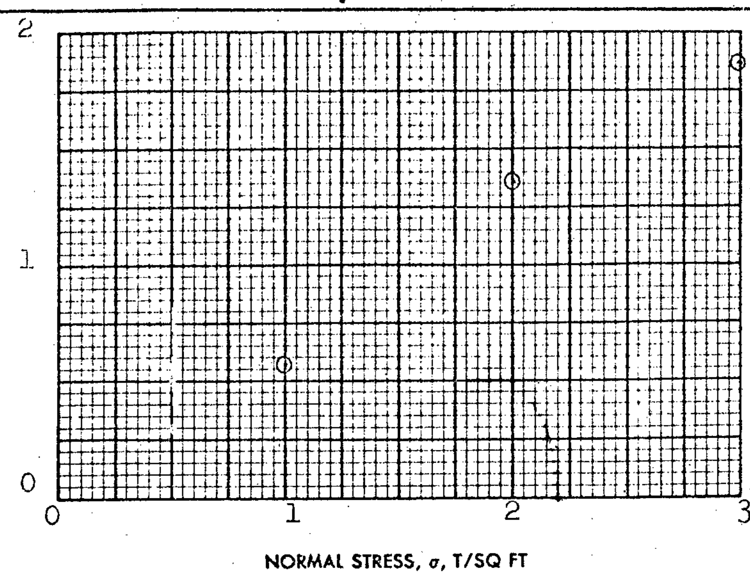
BORING NO. 485-U SAMPLE NO. 3

DEPTH EL 6.0-7.0 DATE 09 APR 78

RCH **DIRECT SHEAR TEST REPORT**

ENG FORM 1 JUN 65 **2092** (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE GPO : 1966 OF—214-945





SHEAR STRENGTH PARAMETERS

ϕ' = ______

TAN ϕ' = ______

c' = ______ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	6.1 %	7.0 %	7.1 %	%
INITIAL	VOID RATIO	e_o	0.694	0.697	0.706	
INITIAL	SATURATION	S_o	23.7 %	27.1 %	27.2 %	%
INITIAL	DRY DENSITY, LB/CU FT	γ_d	99.5	99.3	98.8	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	14.7 %	14.7 %	14.1 %	%
FINAL	VOID RATIO	e_f				
FINAL	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.56	1.36	1.87	
ACTUAL TIME TO FAILURE, MIN		t_f	1230	1200	960	
RATE OF STRAIN, IN./MIN			.00036	.00036	.00036	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

TYPE OF SPECIMEN UNDISTURBED — 3.00 IN. SQUARE — 0.544 IN. THICK

CLASSIFICATION SILTY SAND (SM), BROWN

LL 19 — PL 16 — PI 2 — G_s 2.70

REMARKS

PROJECT DIKE STABILITY

ROCKY MOUNTAIN ARSENAL

AREA

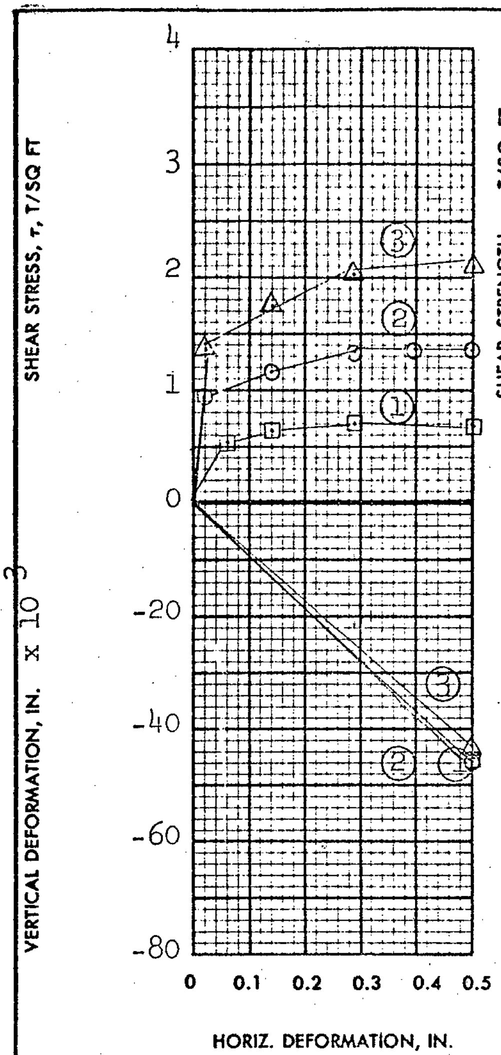
BORING NO. 485-U — SAMPLE NO. 4

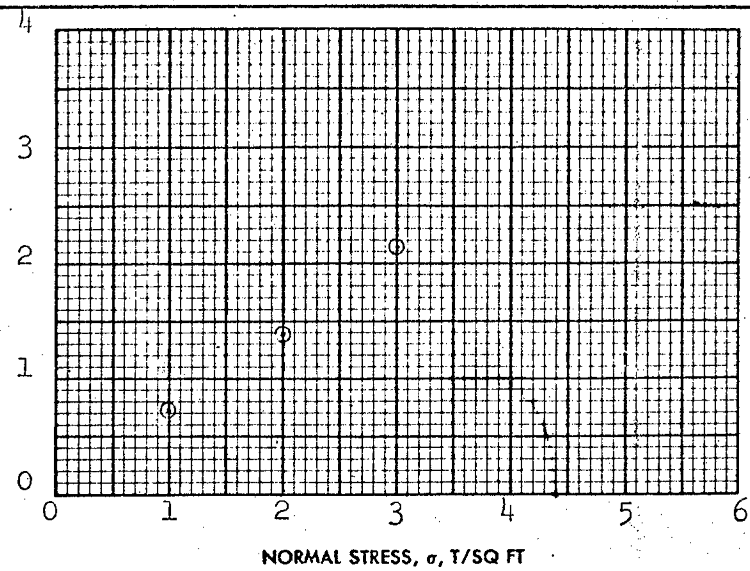
DEPTH EL 10.0-11.0 — DATE 12 APR 78

RCH — **DIRECT SHEAR TEST REPORT**

ENG FORM 1 JUN 65 **2092** (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE

Figure 75





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	7.3 %	7.1 %	7.3 %	%
	VOID RATIO	e_o	0.630	0.614	0.599	
	SATURATION	S_o	31.2 %	31.2%	32.9%	%
	DRY DENSITY, LB/CU FT	γ_d	103.4	104.4	105.4	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	16.9%	16.5 %	14.8 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.71	1.39	2.12	
ACTUAL TIME TO FAILURE, MIN		t_f	1020	1020	1200	
RATE OF STRAIN, IN./MIN			.00032	.00032	.00032	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ____________

TAN ϕ' = ____________

c' = ____________ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED		3.00 IN. SQUARE	0.584 IN. THICK
CLASSIFICATION SILTY SAND (SM), RED			
LL 21	PL 17	PI 4	G_s 2.70

REMARKS ____________

PROJECT DIKE STABILITY
ROCKY MOUNTAIN ARSENAL

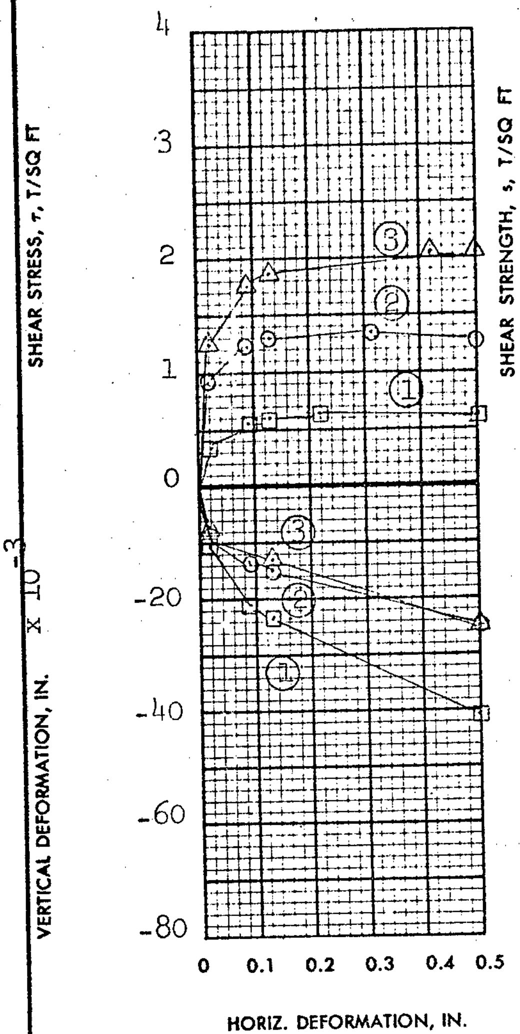
AREA

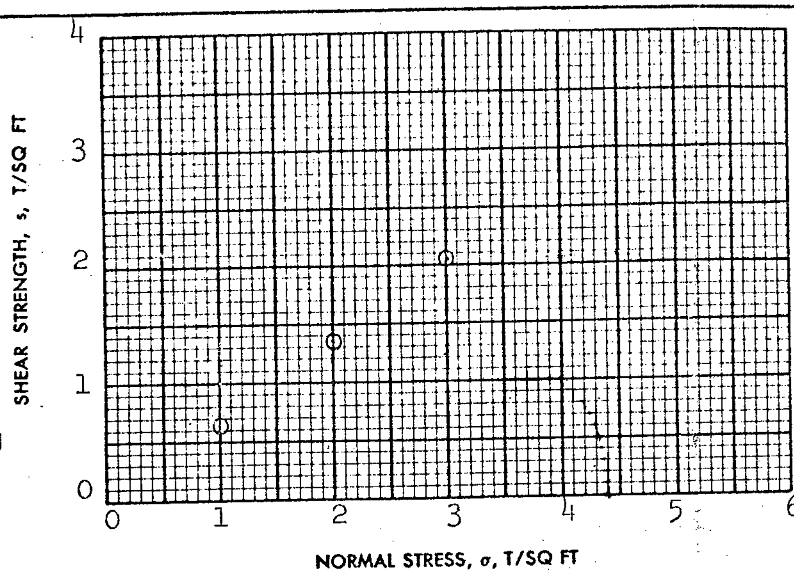
BORING NO. 485-U | SAMPLE NO. 5

DEPTH EL 11.0-12.0 | DATE 11 APR 78

BWG **DIRECT SHEAR TEST REPORT**

ENG FORM 1 JUN 65 **2092** *(EM 1110-2-1906)* PREVIOUS EDITIONS ARE OBSOLETE





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	7.7 %	7.6 %	7.8 %	%
	VOID RATIO	e_o	0.614	0.611	0.625	
	SATURATION	S_o	33.8 %	33.6 %	33.7 %	%
	DRY DENSITY, LB/CU FT	γ_d	104.4	104.6	103.7	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	17.4%	15.2%	15.6%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.64	1.37	2.04	
ACTUAL TIME TO FAILURE, MIN		t_f	630	870	1140	
RATE OF STRAIN, IN./MIN			.00037	.00037	.00037	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ______

TAN ϕ' = ______

c' = ______ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED | 3.00 IN. SQUARE | 0.544 IN. THICK

CLASSIFICATION SILTY SAND (SM), BROWN

LL 21 | PL 17 | PI 4 | G_s 2.70

REMARKS

PROJECT DIKE STABILITY

ROCKY MOUNTAIN ARSENAL

AREA

BORING NO. 485-U | SAMPLE NO. 6

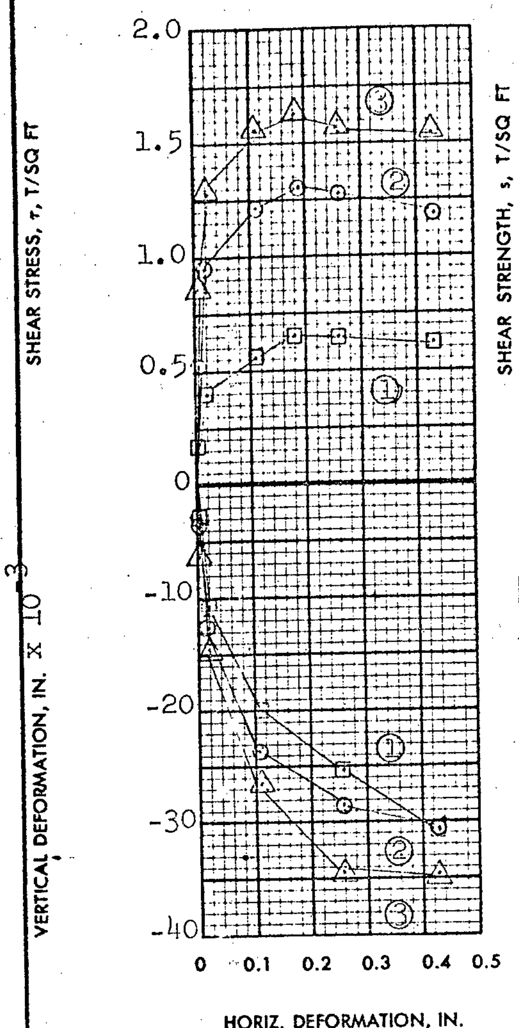
DEPTH/EL 15.7-17.0 | DATE 12 APR 78

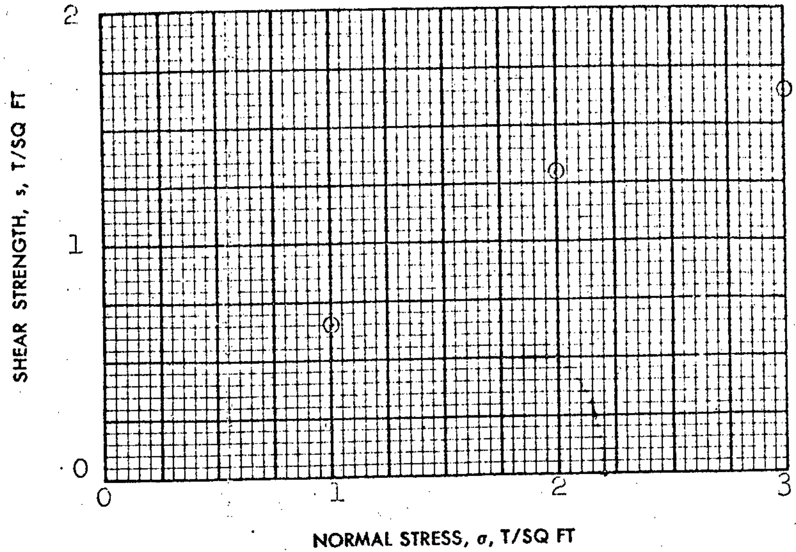
RCH

DIRECT SHEAR TEST REPORT

ENG FORM 1 JUN 65 **2092** *(EM 1110-2-1906)* PREVIOUS EDITIONS ARE OBSOLETE

GPO : 1966 OF—214-945





TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	17.1%	17.3%	17.9%	%
	VOID RATIO	e_o	0.752	0.706	0.743	
	SATURATION	S_o	62.1%	66.9%	65.7%	%
	DRY DENSITY, LB/CU FT	γ_d	97.3	99.9	97.8	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	10	4	4	
FINAL	WATER CONTENT	w_f	24.3%	23.6%	22.2%	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.65	1.30	1.64	
ACTUAL TIME TO FAILURE, MIN		t_f	1890	1260	1170	
RATE OF STRAIN, IN./MIN			.00016	.00016	.00016	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

SHEAR STRENGTH PARAMETERS

ϕ' = ________

TAN ϕ' = ________

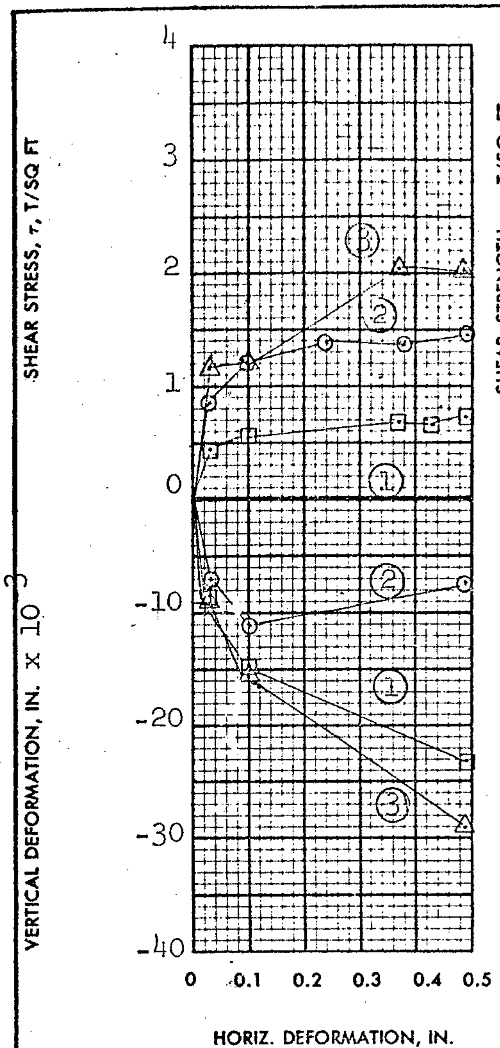
c' = ________ T/SQ FT

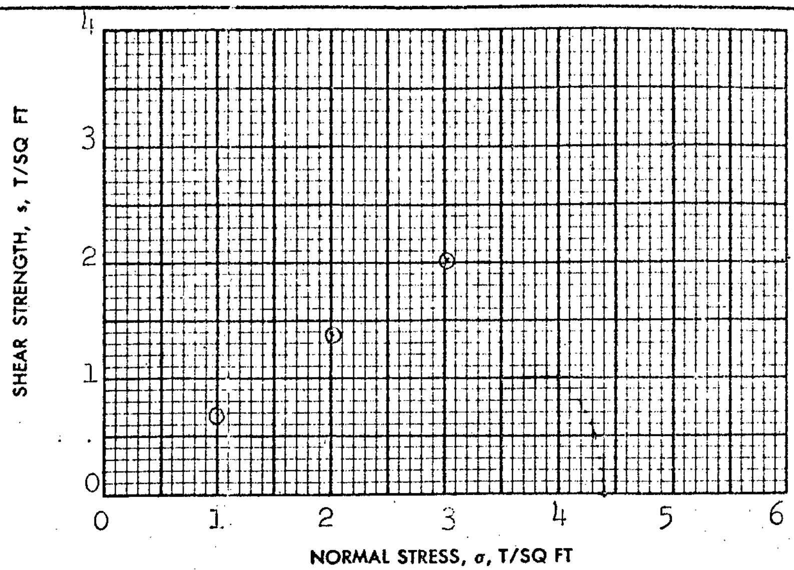
☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TYPE OF SPECIMEN UNDISTURBED		3.00 IN. SQUARE	0.584 IN. THICK
CLASSIFICATION SANDY SILTY CLAY(CL), TAN AND RED MARBLED			
LL 40	PL 15	PI 25	G_s 2.73

REMARKS	PROJECT DIKE STABILITY ROCKY MOUNTAIN ARSENAL	
	AREA	
	BORING NO. 485-U	SAMPLE NO. 7
	DEPTH/EL 20.35-21.6	DATE 12 APR 78
	BWG	**DIRECT SHEAR TEST REPORT**





SHEAR STRENGTH PARAMETERS

ϕ' = ______

TAN ϕ' = ______

c' = ______ T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	w_o	16.4%	16.7%	15.6 %	%
	VOID RATIO	e_o	0.561	0.564	0.551	
	SATURATION	S_o	79.5%	80.5%	77.0 %	%
	DRY DENSITY, LB/CU FT	γ_d	108.8	108.6	109.5	
VOID RATIO AFTER CONSOLIDATION		e_c				
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}				
FINAL	WATER CONTENT	w_f	16.2%	14.5%	13.1 %	%
	VOID RATIO	e_f				
	SATURATION	S_f	%	%	%	%
NORMAL STRESS, T/SQ FT		σ	1.0	2.0	3.0	
MAXIMUM SHEAR STRESS, T/SQ FT		τ_{max}	0.69	1.39	2.02	
ACTUAL TIME TO FAILURE, MIN		t_f	1080	1080	1080	
RATE OF STRAIN, IN./MIN			.00031	.00031	.00031	
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}				

TYPE OF SPECIMEN UNDISTURBED	3.00 IN. SQUARE	0.544 IN. THICK	
CLASSIFICATION CLAYEY SANDY GRAVEL (GC), BROWN			
LL 36	PL 14	PI 22	G. 2.72

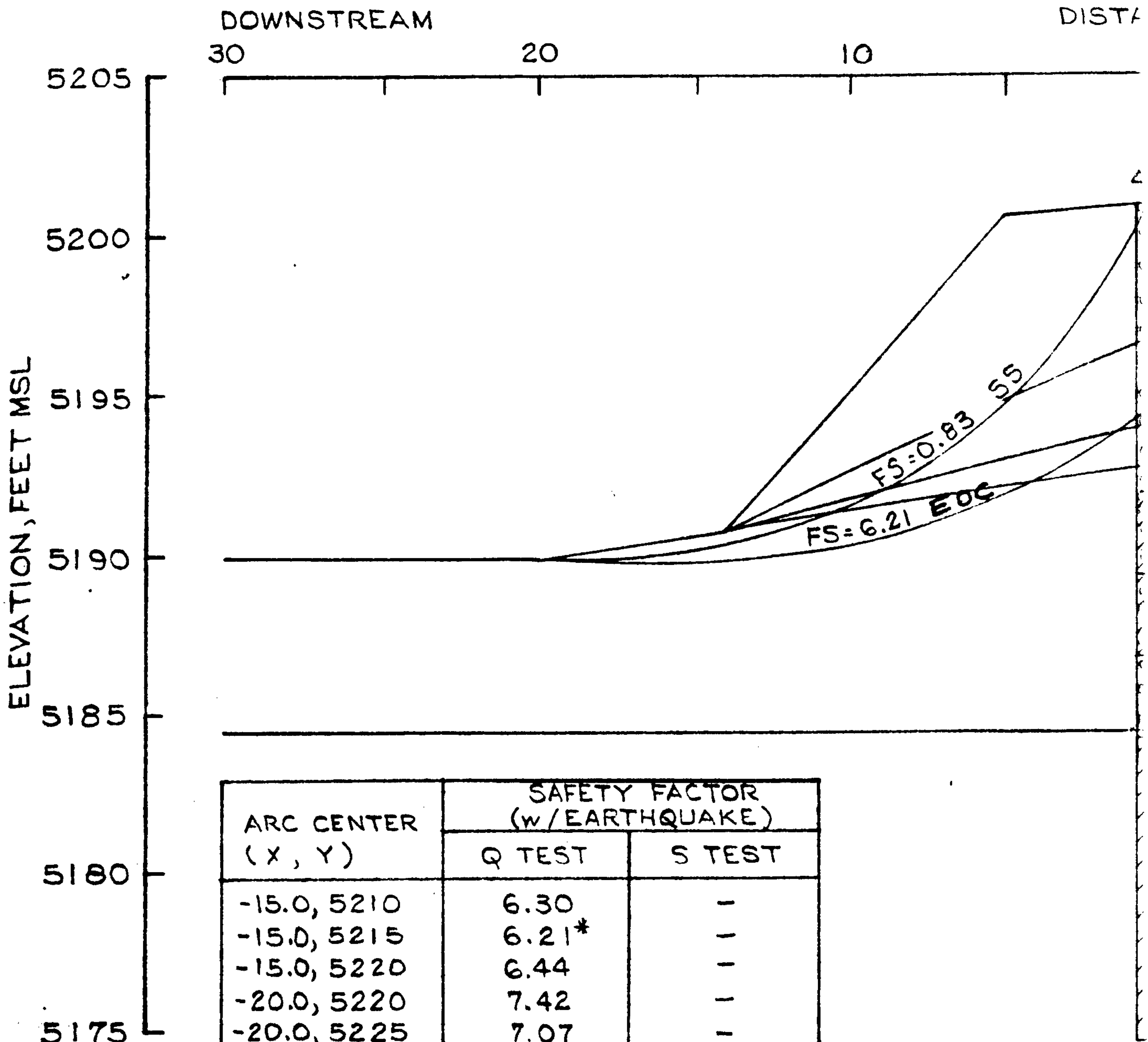
REMARKS

PROJECT	DIKE STABILITY
	ROCKY MOUNTAIN ARSENAL
AREA	
BORING NO. 485-U	SAMPLE NO. 8
DEPTH FT 25.3-26.1	DATE 13 APR 78
RCH	**DIRECT SHEAR TEST REPORT**

ENG FORM 1 JUN 65 **2092** (EM 1110-2-1906) PREVIOUS EDITIONS ARE OBSOLETE

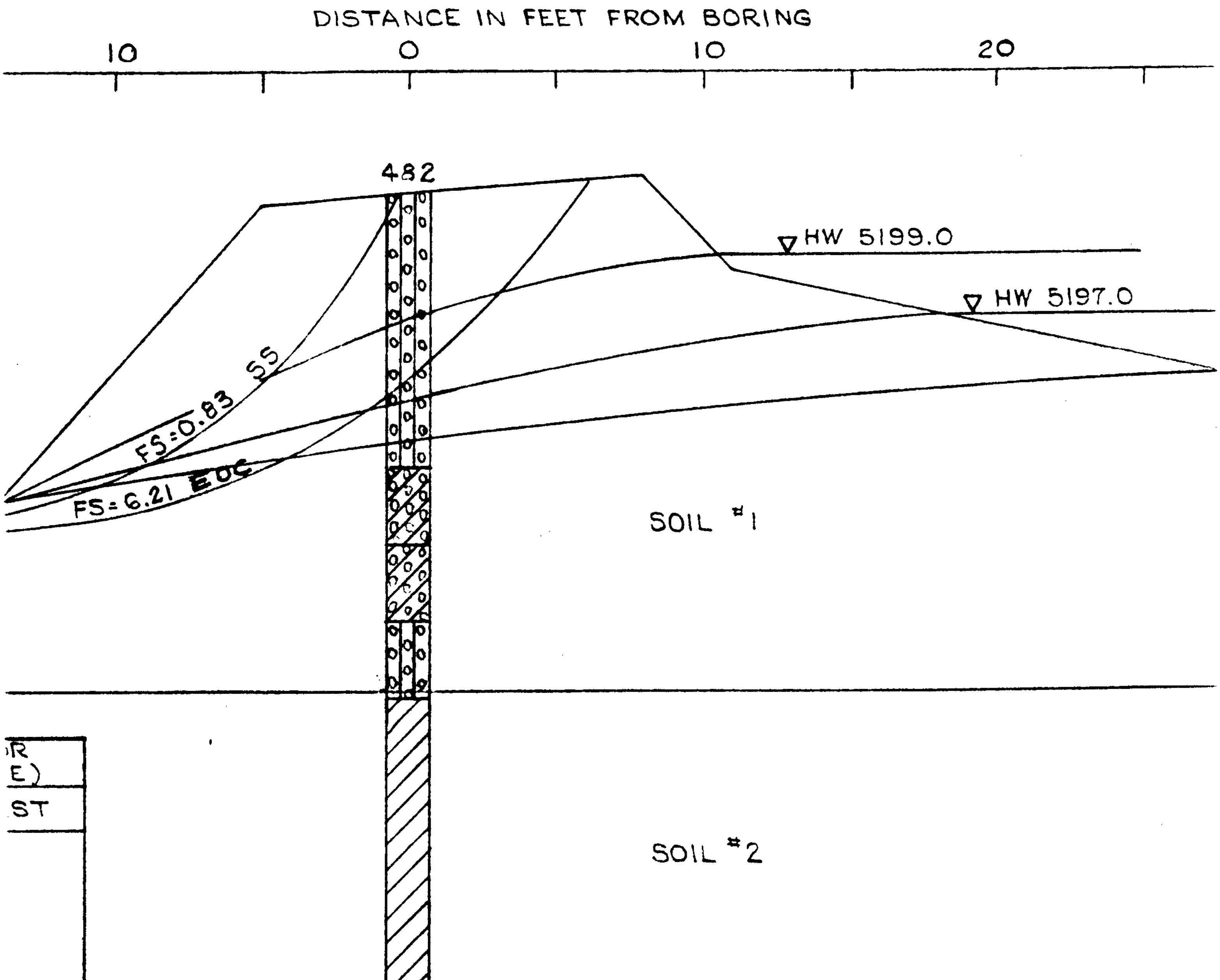
GPO : 1966 OF—214-945

Figure 79



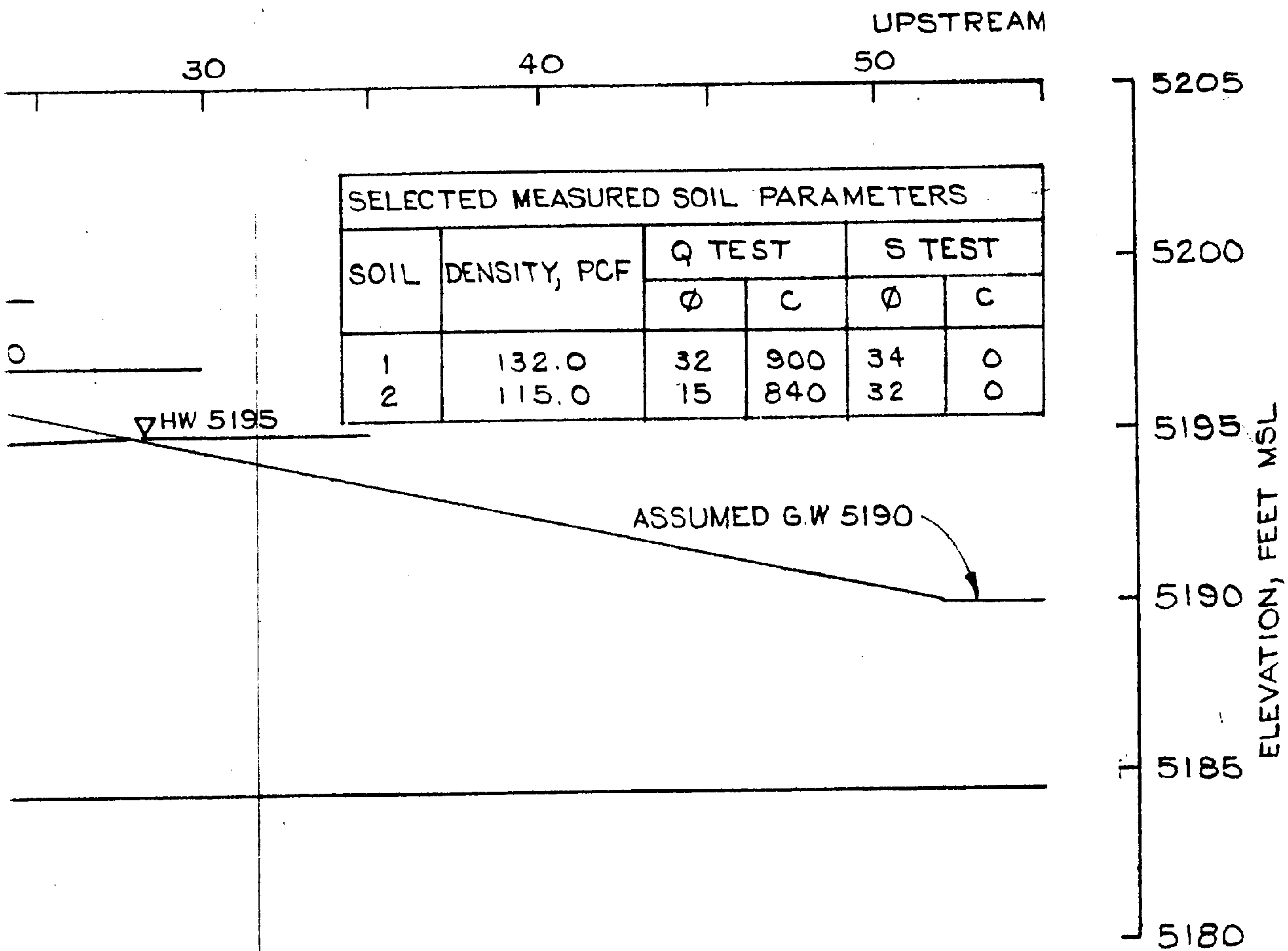
ARC CENTER (X, Y)	SAFETY FACTOR (w/EARTHQUAKE)	
	Q TEST	S TEST
-15.0, 5210	6.30	–
-15.0, 5215	6.21*	–
-15.0, 5220	6.44	–
-20.0, 5220	7.42	–
-20.0, 5225	7.07	–
-10.0, 5215	6.91	–
-17.5, 5209	–	0.83*
-12.5, 5207.5	–	1.10
-10.0, 5207.5	–	1.38
-15.0, 5210	–	0.97
-12.5, 5210	–	1.15

*MINIMUM



R E)
ST
33* 0 38 37 5

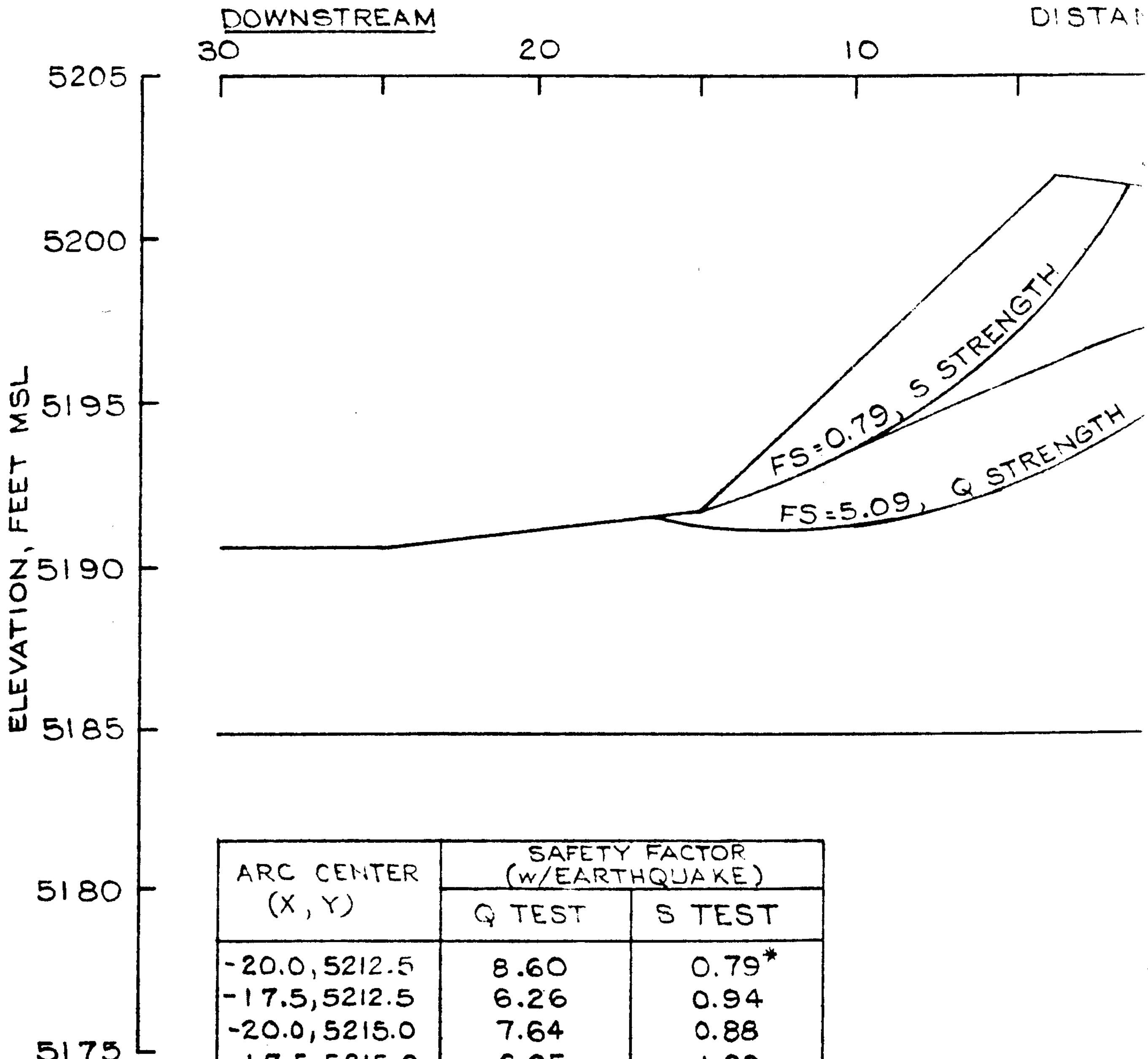
9



SELECTED MEASURED SOIL PARAMETERS					
SOIL	DENSITY, PCF	Q TEST		S TEST	
		Ø	C	Ø	C
1	132.0	32	900	34	0
2	115.0	15	840	32	0

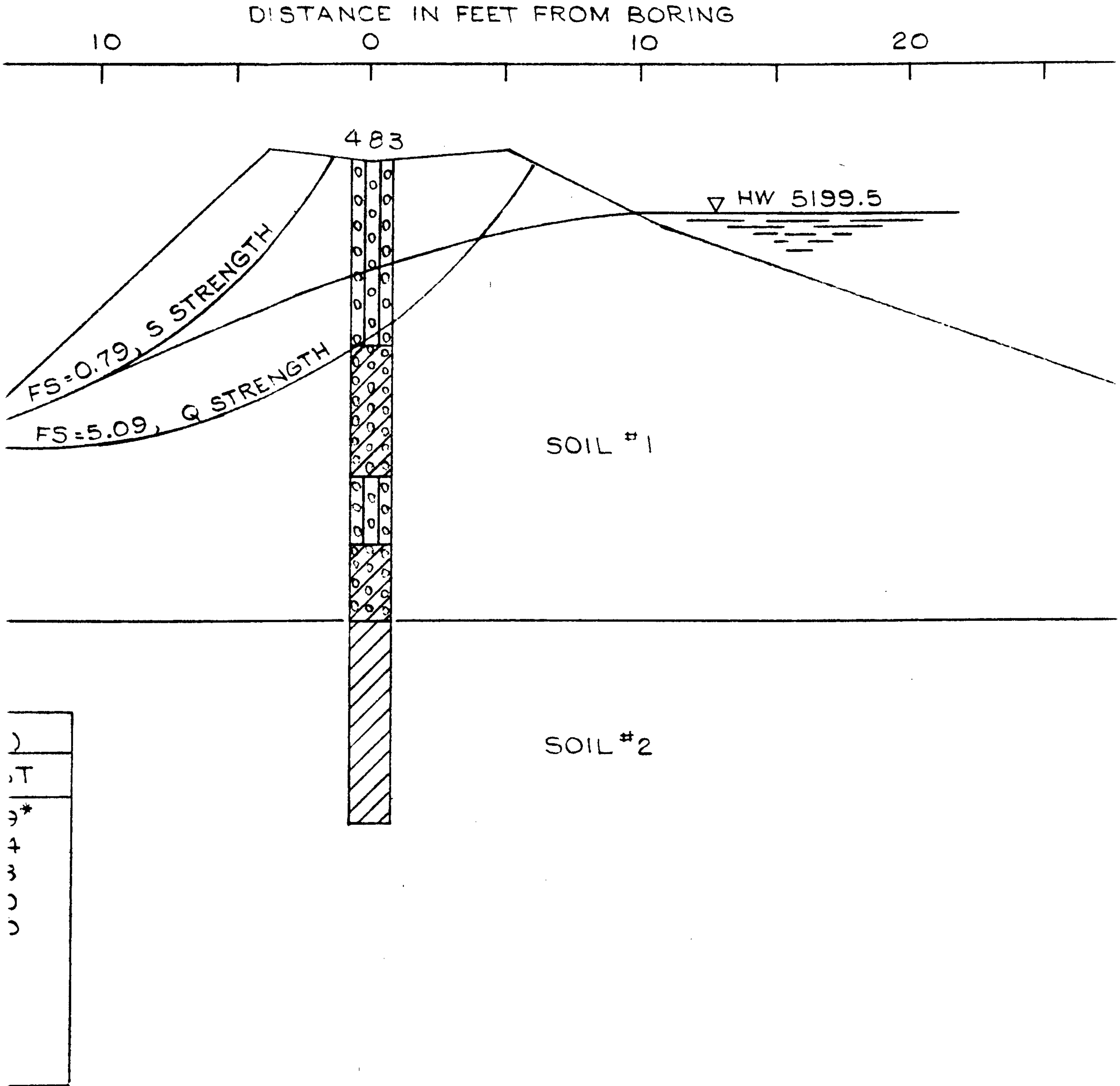
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

3

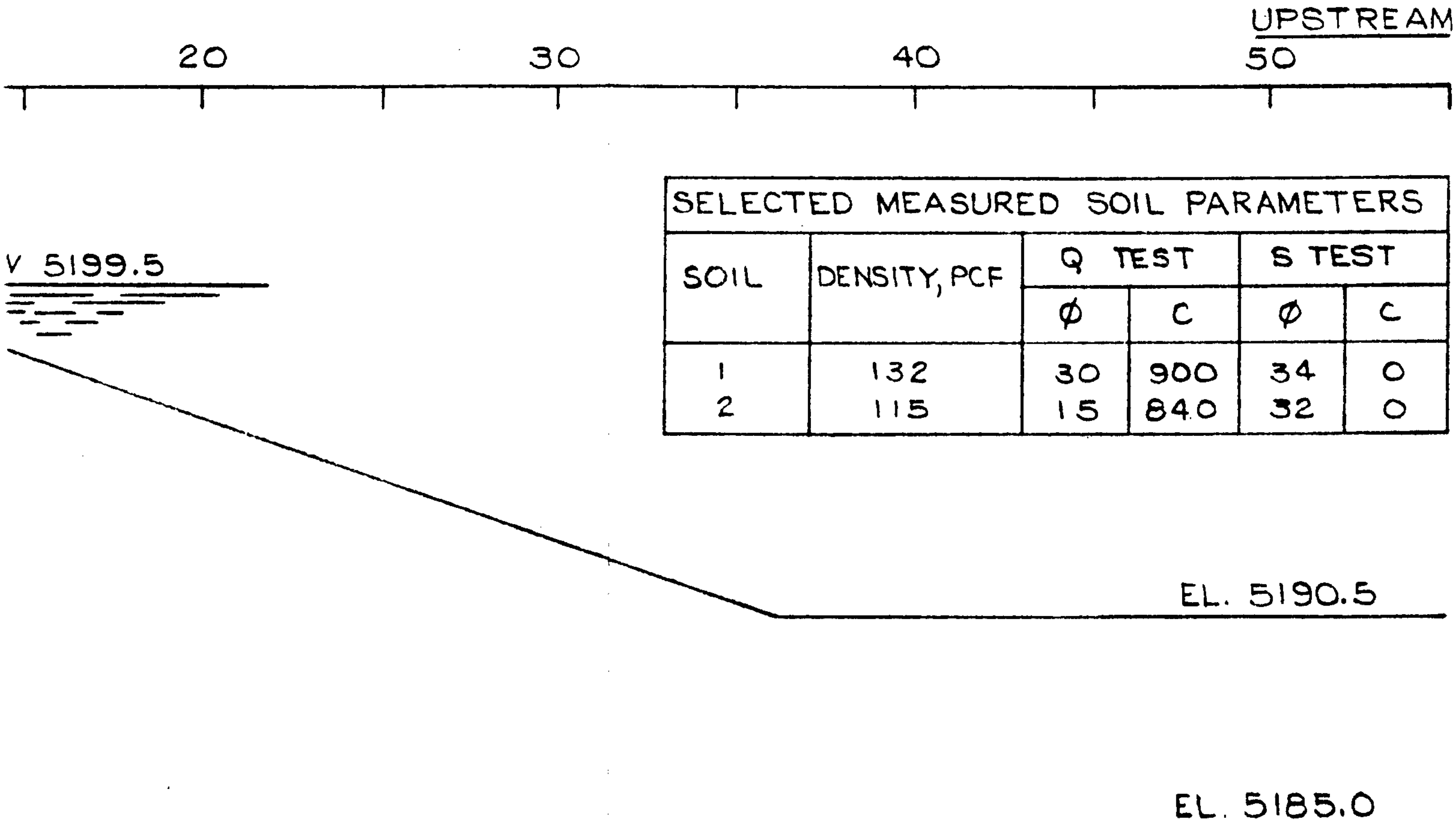


ARC CENTER (X, Y)	SAFETY FACTOR (w/EARTHQUAKE)	
	Q TEST	S TEST
-20.0, 5212.5	8.60	0.79*
-17.5, 5212.5	6.26	0.94
-20.0, 5215.0	7.64	0.88
-17.5, 5215.0	6.05	1.00
-20.0, 5217.5	7.11	0.90
-12.5, 5210.0	5.10	-
-12.5, 5212.5	5.09*	-
-12.5, 5215.0	5.12	-
-15.0, 5212.5	5.41	-
-10.0, 5212.5	5.14	-

*MINIMUM


DISTANCE IN FEET FROM BORING
10
0
10
20
483
HW 5199.5
FS=0.79, S STRENGTH
FS=5.09, Q STRENGTH
SOIL #1
SOIL #2
)
,T
9*
4
3
)
)

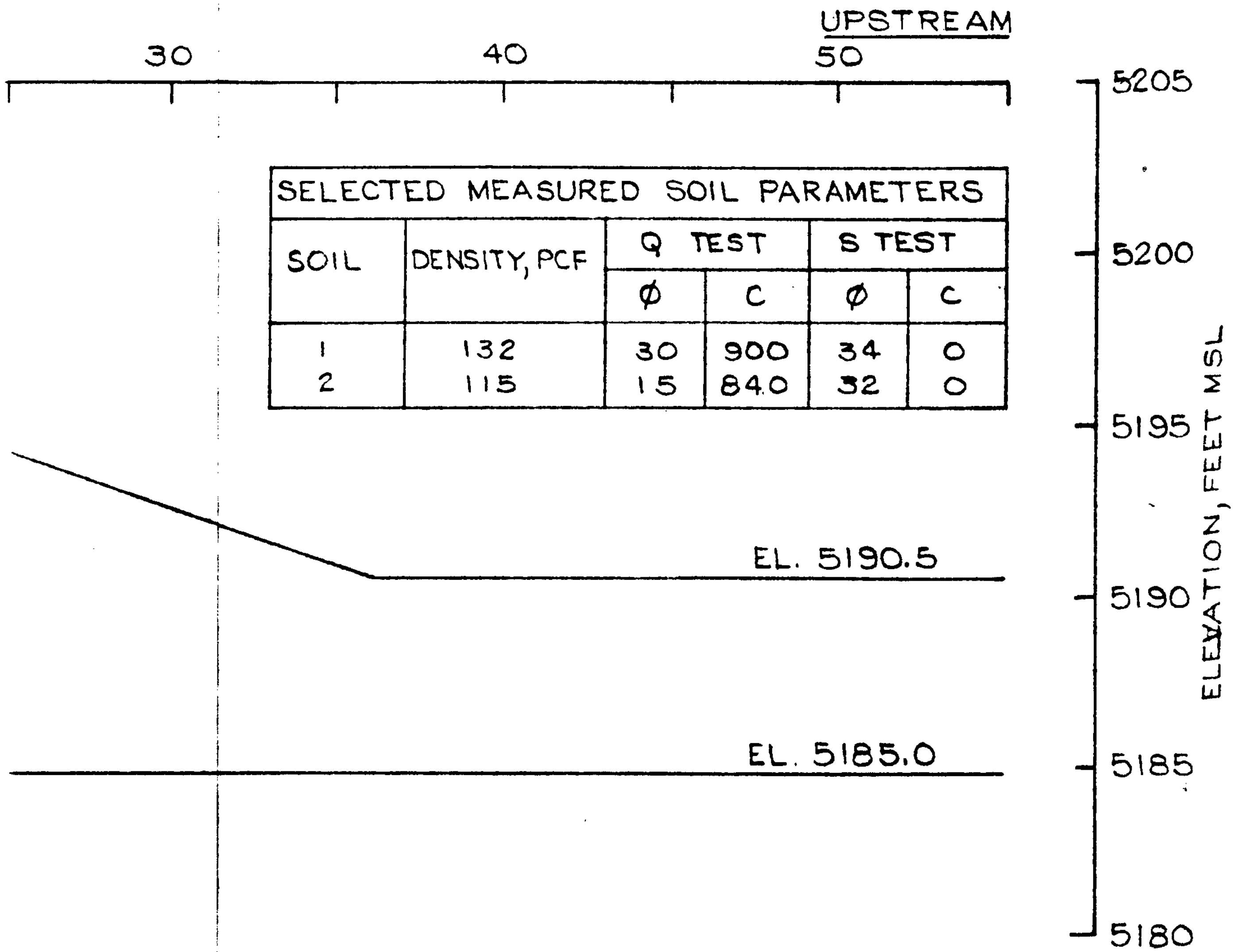
2



SELECTED MEASURED SOIL PARAMETERS					
SOIL	DENSITY, PCF	Q TEST		S TEST	
		φ	C	φ	C
1	132	30	900	34	0
2	115	15	840	32	0

DIKE STABILITY
BASIN F
ROCKY MOUNTAIN
DENVER, COLO

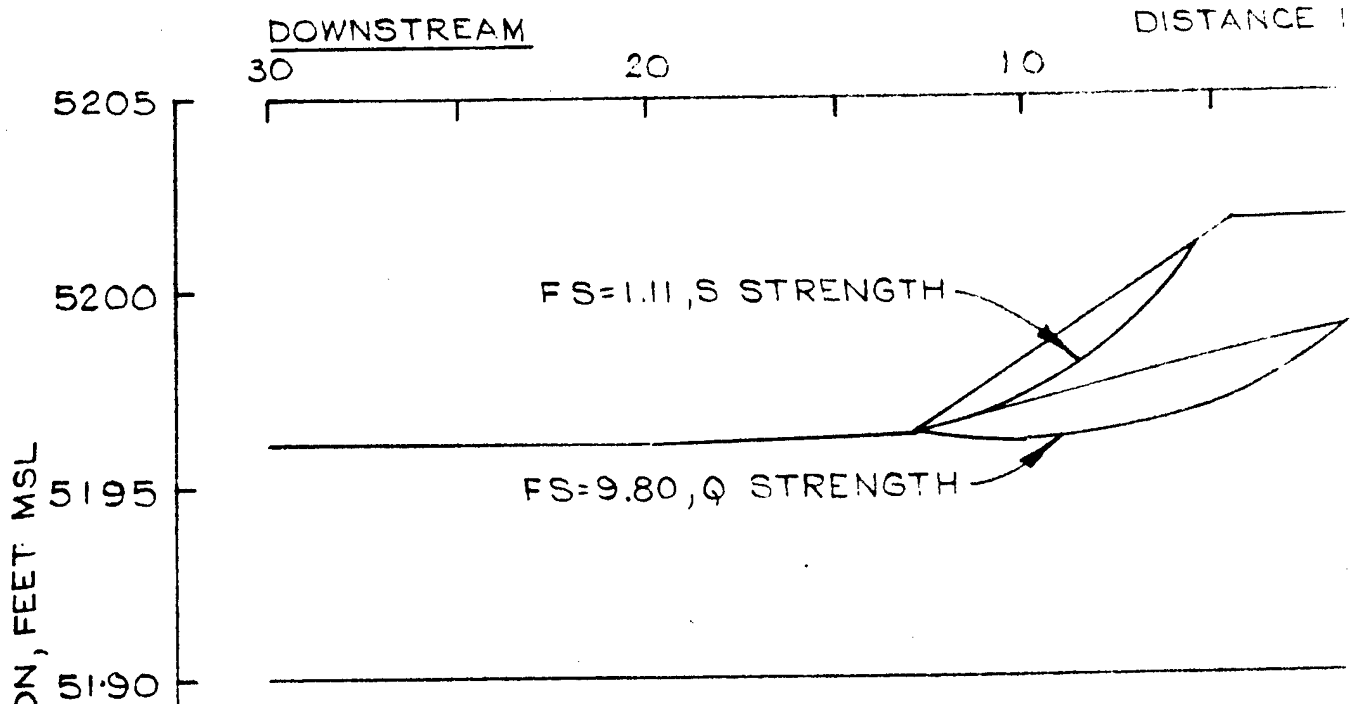
3



SELECTED MEASURED SOIL PARAMETERS

SOIL	DENSITY, PCF	Q TEST		S TEST	
		Ø	C	Ø	C
1	132	30	900	34	0
2	115	15	840	32	0

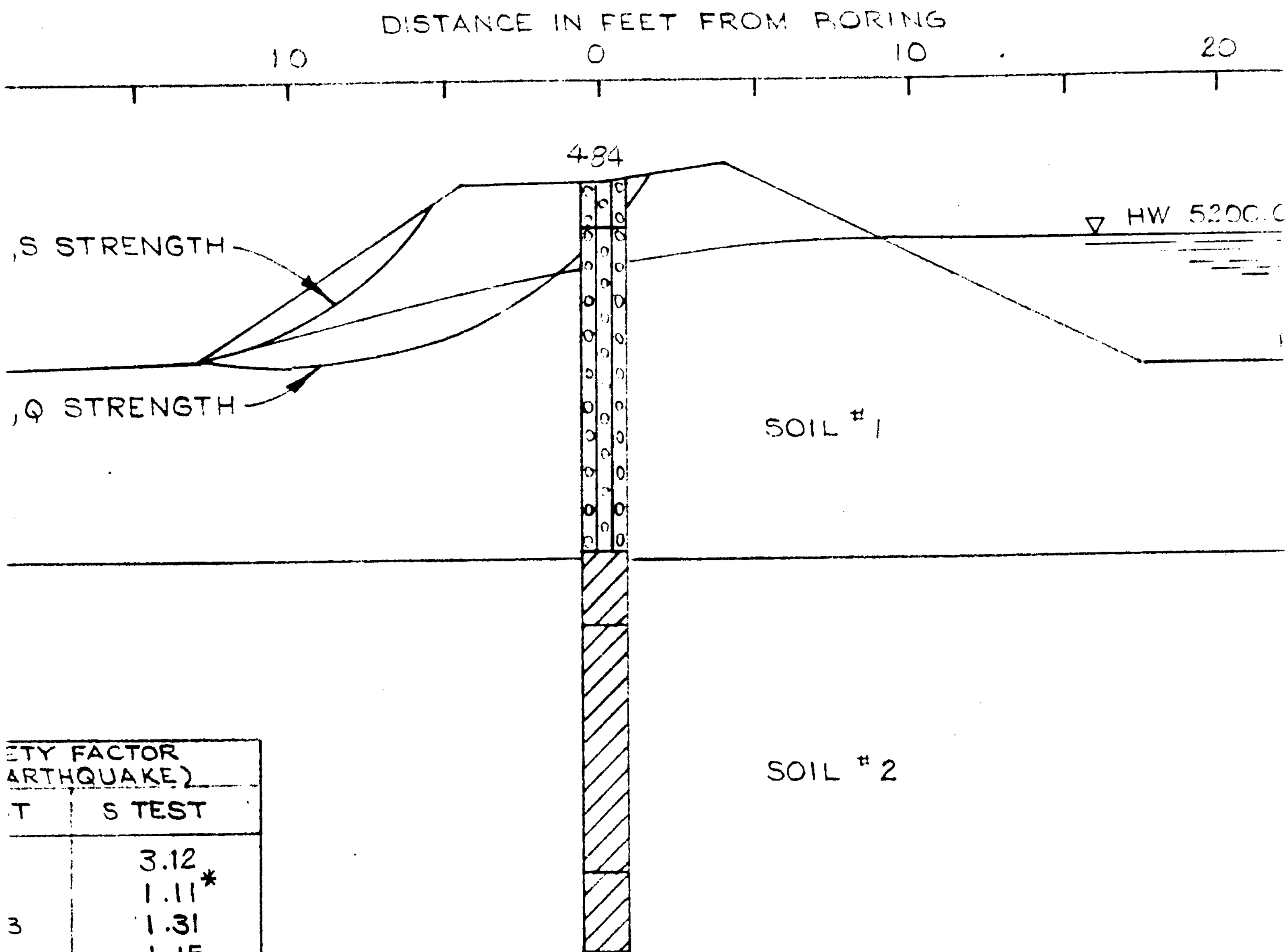
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO



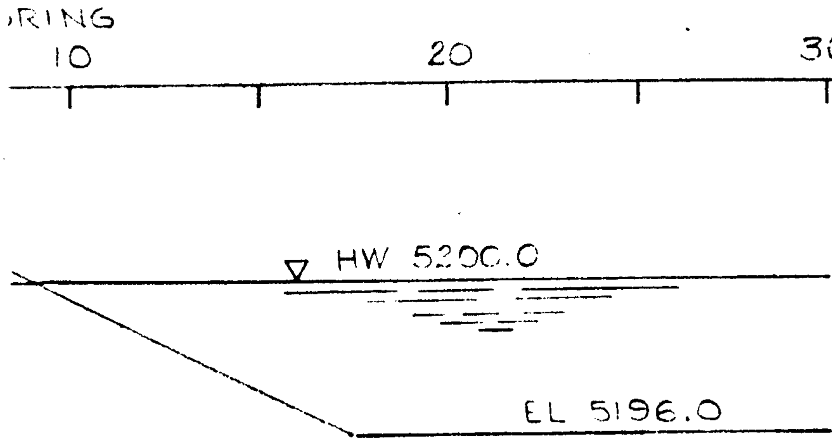
ARC CENTER (X, Y)	SAFETY FACTOR (w/ EARTHQUAKE)	
	Q TEST	S TEST
-17.5, 5207.5	-	3.12
-15.0, 5207.5	-	1.11*
-12.5, 5207.5	12.53	1.31
-15.0, 5205.0	-	1.15
-15.0, 5210.0	21.34	1.12
-12.5, 5210.0	11.70	-
-10.0, 5210.0	9.80*	-
- 7.5, 5210.0	11.13	-
- 5.0, 5210.0	14.84	-
- 7.5, 5207.5	11.65	-
- 7.5, 5212.5	10.89	-

*MINIMUM

1



ETY FACTOR ARTHQUAKE)	
T	S TEST
	3.12
	1.11*
3	1.31
	1.15
4	1.12
0	–
0*	–
3	–
4	–
5	–
9	–



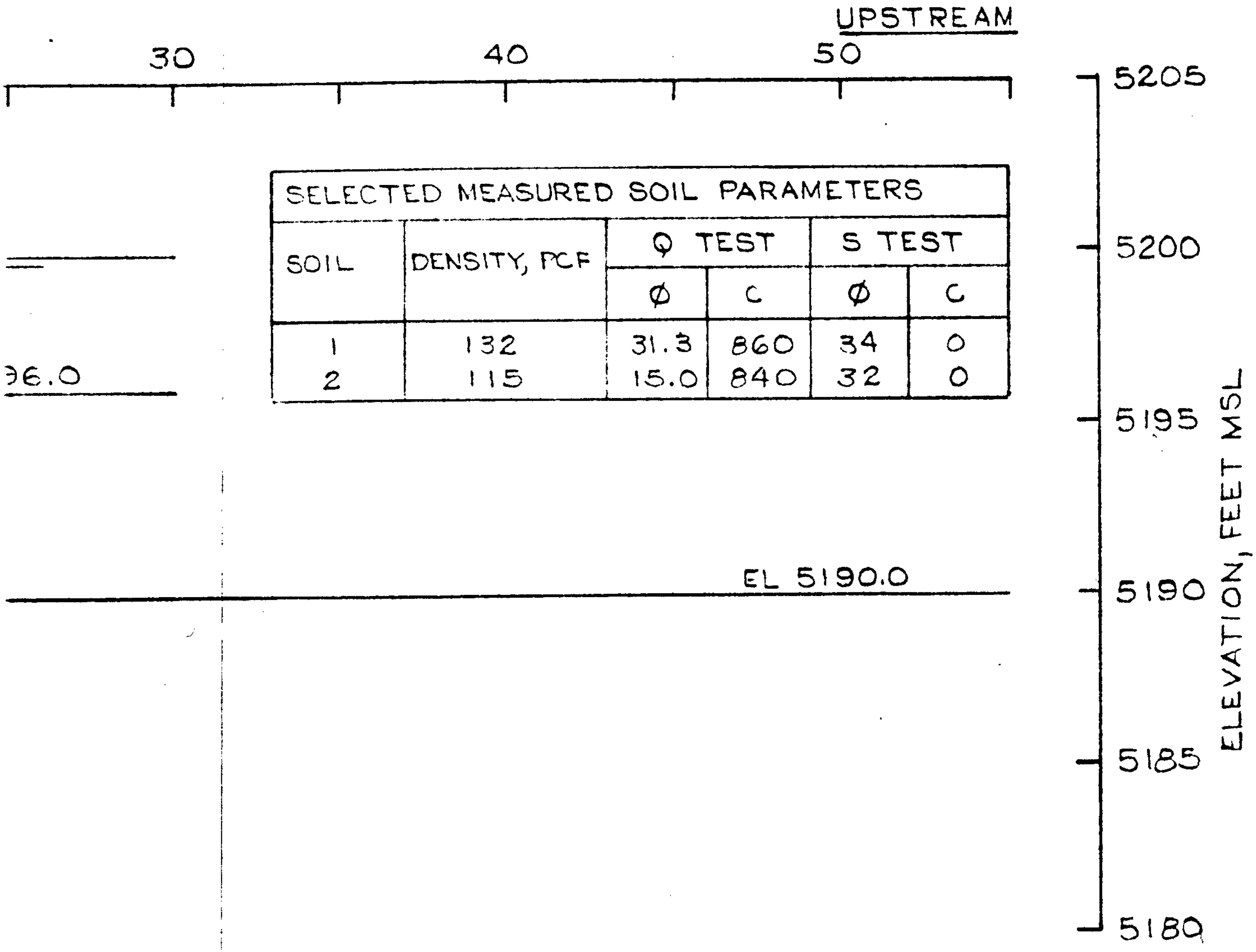
SELECTED MEASURED SOIL PARAM			
SOIL	DENSITY, PCF	Q TEST	
		Ø	C
1	132	31.3	860
2	115	15.0	840

#1

EL 5

#2

3

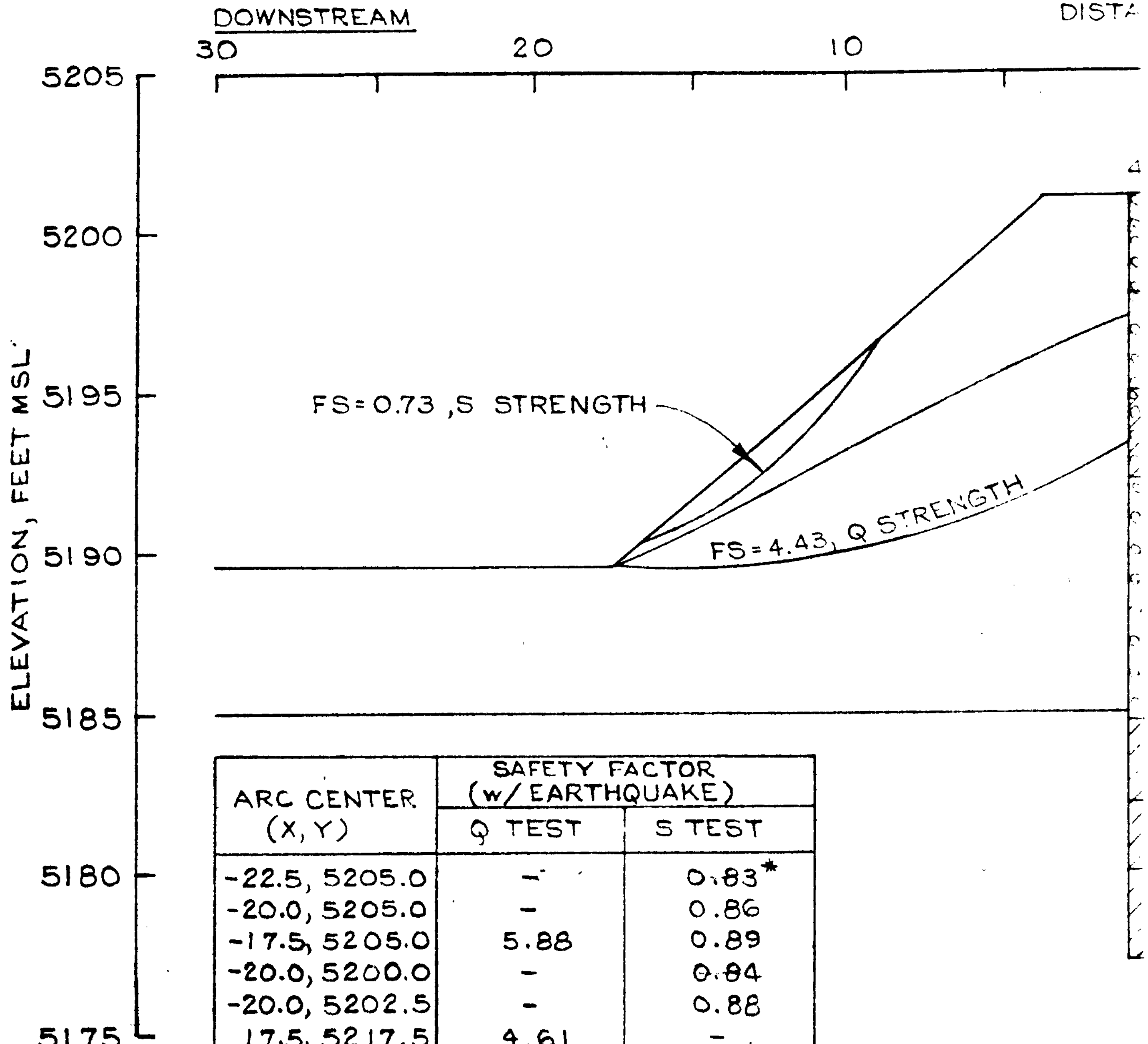


SELECTED MEASURED SOIL PARAMETERS					
SOIL	DENSITY, PCF	Q TEST		S TEST	
		Ø	C	Ø	C
1	132	31.3	860	34	0
2	115	15.0	840	32	0

DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

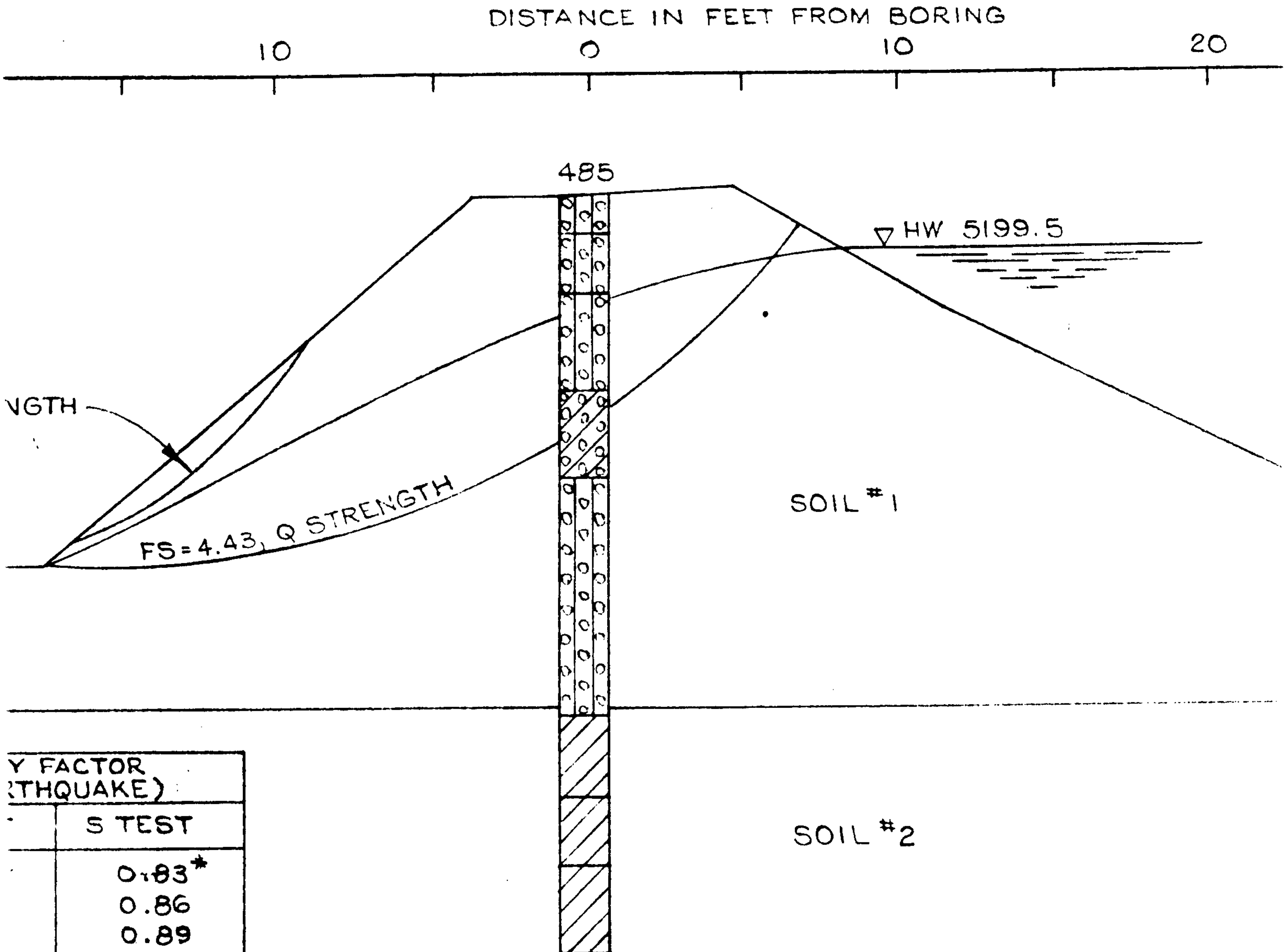
Figure [illegible]

4



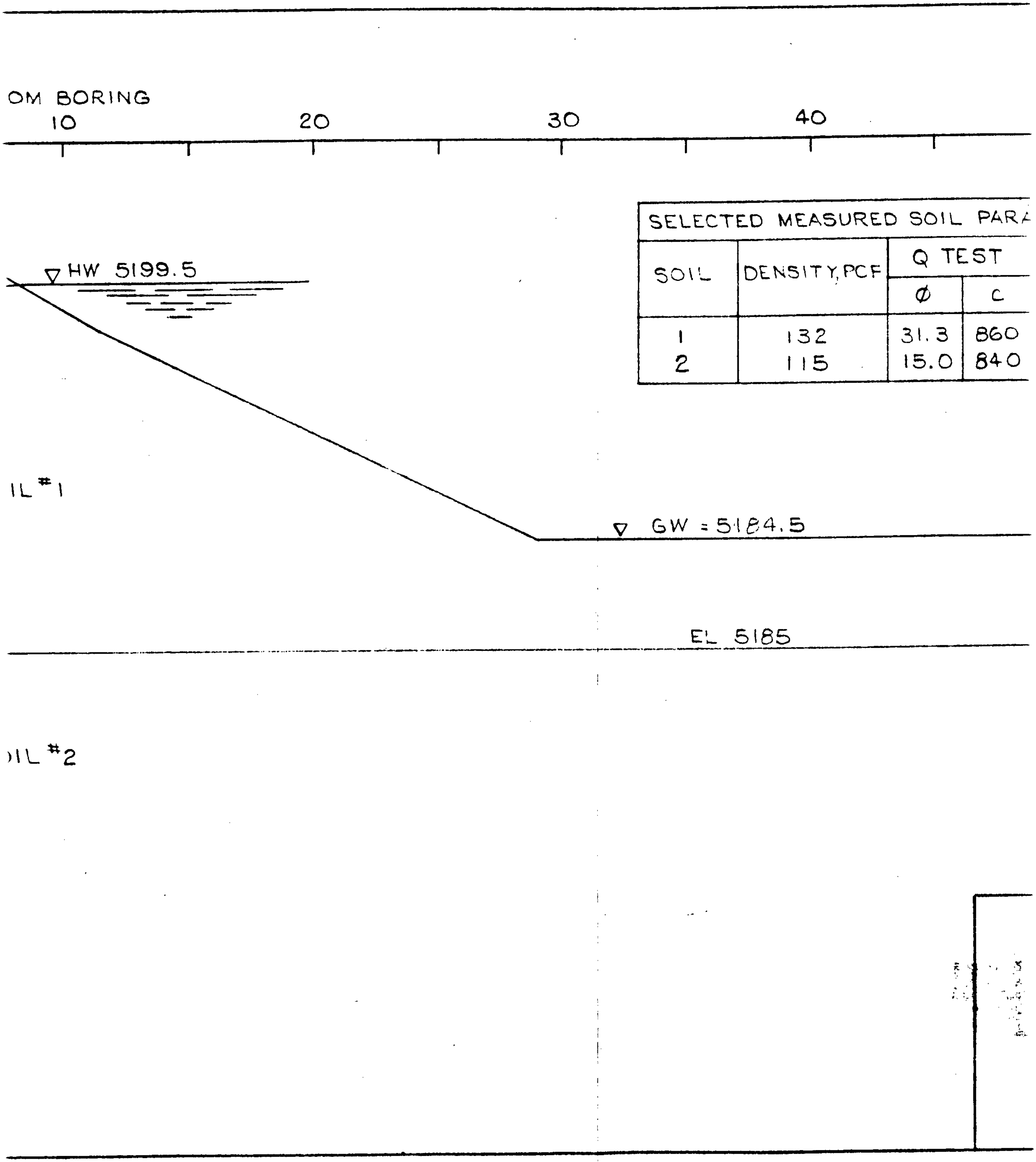
ARC CENTER (X, Y)	SAFETY FACTOR (w/ EARTHQUAKE) Q TEST	S TEST
-22.5, 5205.0	–	0.83*
-20.0, 5205.0	–	0.86
-17.5, 5205.0	5.88	0.89
-20.0, 5200.0	–	0.84
-20.0, 5202.5	–	0.88
17.5, 5217.5	4.61	–
15.0, 5217.5	4.43*	–
12.5, 5217.5	4.59	–
15.0, 5215.0	4.44	–
15.0, 5220.0	4.45	–

*MINIMUM



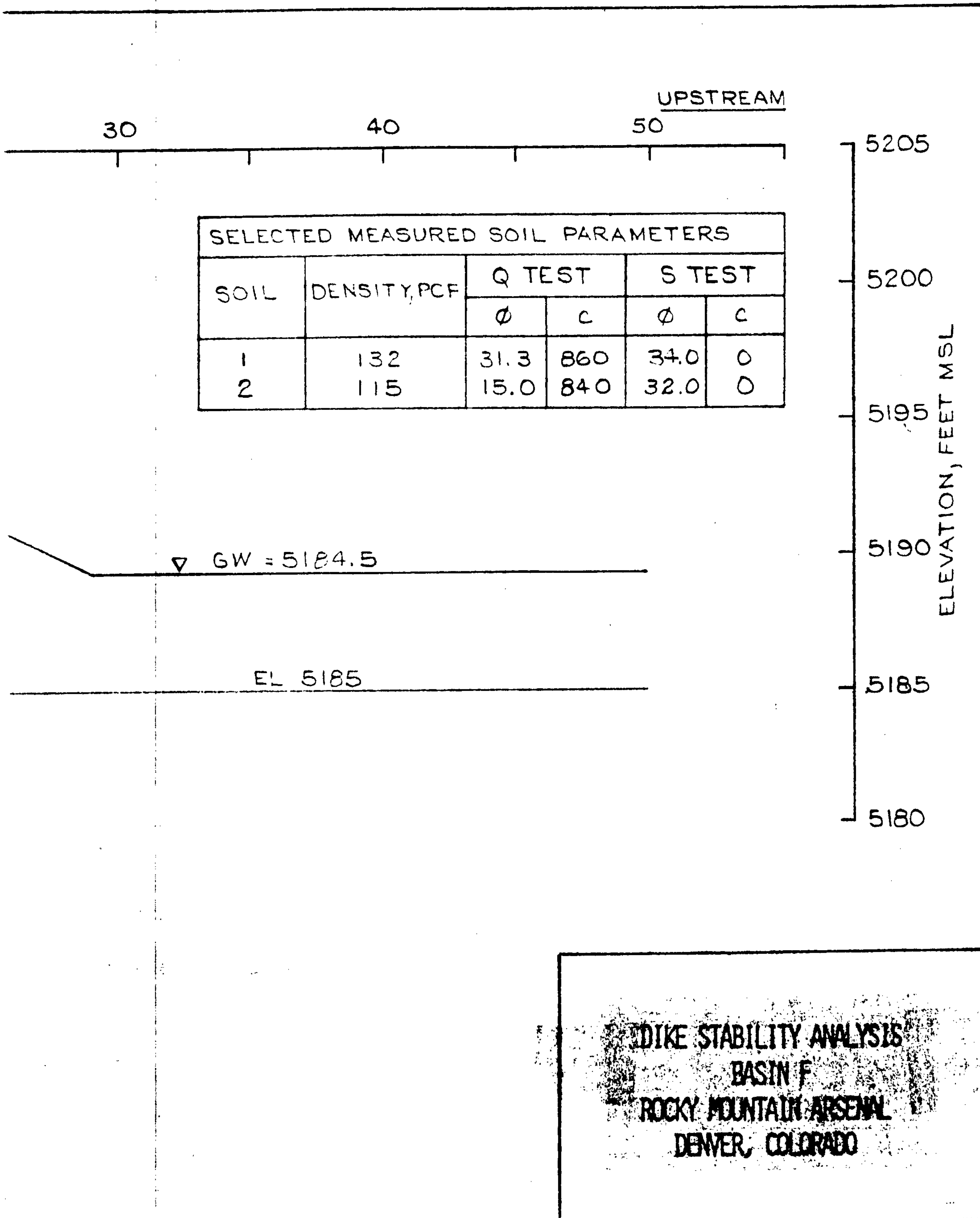
Y FACTOR (THQUAKE)	
-	S TEST
	0.83*
	0.86
	0.89
	0.84
	0.88
	–
*	–
	–
	–
)	–

2



SELECTED MEASURED SOIL PARA			
SOIL	DENSITY, PCF	Q TEST	
		∅	c
1	132	31.3	860
2	115	15.0	840

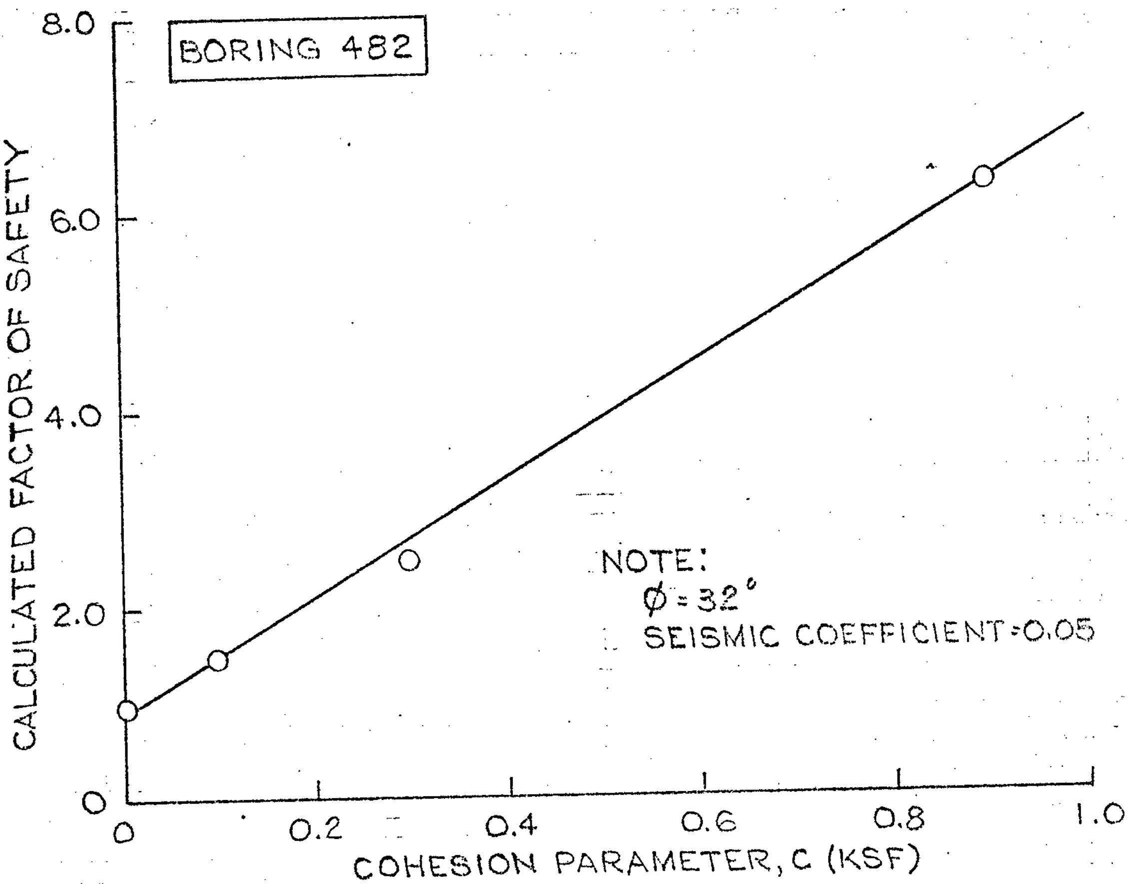
3



SELECTED MEASURED SOIL PARAMETERS					
SOIL	DENSITY, PCF	Q TEST		S TEST	
		Ø	c	Ø	c
1	132	31.3	860	34.0	0
2	115	15.0	840	32.0	0

DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

4



COHESION SENSITIVITY
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

Figure 84

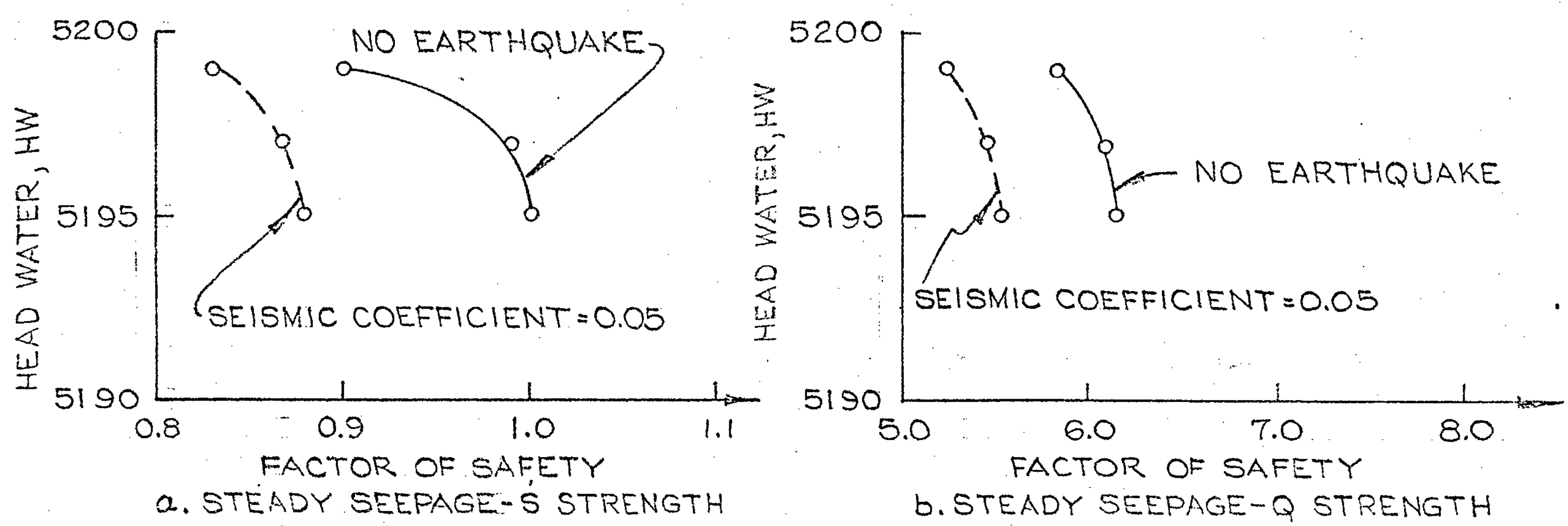
Boring	Shear Strength Source	Minimum Safety Factors		
		Upstream Slope	Downstream Slope	
		Q-test	Q-test	S-test
482	Estimated	1.87	–	0.87
	Measured	–	5.21*	0.83*
483	Estimated	1.97	–	1.02
	Measured	–	5.09*	0.79*
484	Estimated	1.78	–	1.25
	Measured	–	9.80*	1.11*
485	Estimated	1.79	–	0.93
	Measured	–	4.43*	0.73*

* seismic coefficient - 0.05

SUMMARY OF FACTORS OF SAFETY
DIKE STABILITY ANALYSIS
BASIN F

ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

Figure 85



POOL ELEVATION VS FACTOR OF SAFETY
DIKE STABILITY ANALYSIS
BASIN F
ROCKY MOUNTAIN ARSENAL
DENVER, COLORADO

Figure 86